ECOTHINGS MANUAL

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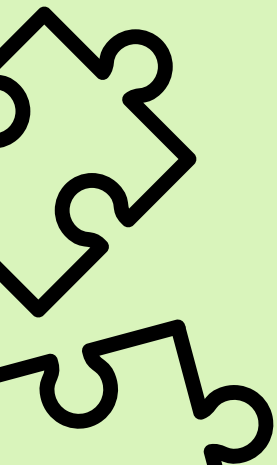
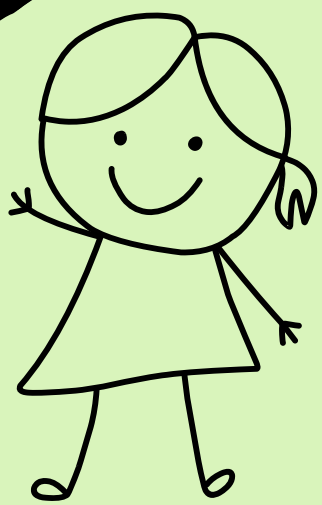
Pedagogical Methodologies
&
Implementation Guidelines,
for Primary and Secondary Schools





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The Polytechnic University of Valencia is a prominent institution with a focus on international cooperation, technological education, and a strong commitment to academic excellence. UPV, known for its technological leadership, offers a wide range of programs, has extensive experience in managing European projects.

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WYLIODRIN SRL

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Wyliodrin specializes in IT and offers an educational platform for programming embedded devices. Their services are designed to help beginners grasp fundamental IoT concepts, making this field more accessible to students and future IoT specialists.

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Turan Erdogan Yılmaz Science High School in Turkey provides a rigorous curriculum with a focus on science and mathematics. They have experience in coding, robotics, and environmental projects and are dedicated to promoting international collaboration and student integration into the global community.

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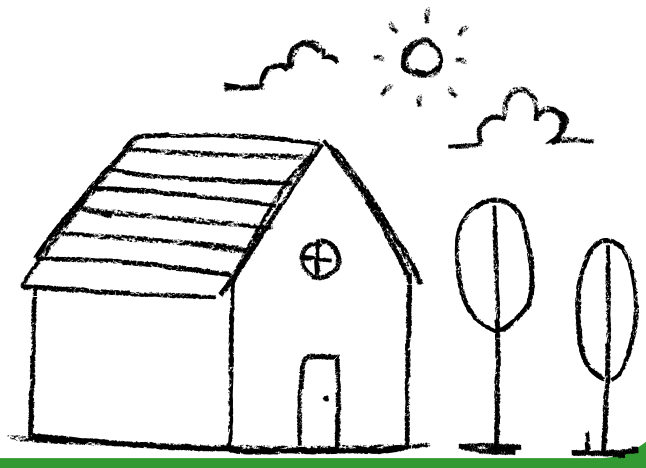

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INTRODUCTION

Nowadays, there is a worldwide acknowledgment that our education system is quickly becoming outdated: criticisms are spreading from different societal sectors, blaming it for not helping develop the natural skills that children possess, for using a content-based curriculum, for stressing the importance of quantitative assessment, etc. Such criticisms are expressed by parents' associations, companies, the pupils/students, and even the teachers themselves, confined to mere content providers and thus unable to carry out effective and innovative pedagogical practice.

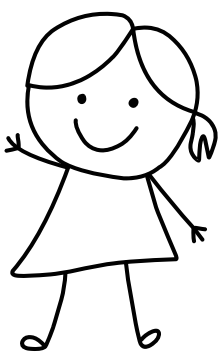
Initiatives like PISA (Programme for International Student Assessment) have played a significant role in granting outstanding relevance to school tests as the only undisputed way to evaluate entire national school systems. This has placed considerable pressure on students, teachers, and headmasters, forcing them to focus on quantity rather than quality, on content rather than skills, and on summative evaluation rather than methodology.

This Pedagogical Manual aims to enable teachers to master the technical and pedagogical skills necessary to enrich their teaching and learning activities in classrooms and to develop their own technological activities with innovative, student-centered, project-based and constructivist pedagogical

approaches, putting pupils and students back at the centre of their learning process, with a focus on preventing school failure and early school leaving. We are basically talking about inductive vs. deductive; student-based vs. teacher-based; personalised vs. collectivised; active vs. passive learning.

The Manual will be an integrated technological and pedagogical guide designed to optimise the use of the innovative technology proposed in the EcoTHINGS project. Its focus is not only on teaching how to use specific hardware and software for environmental purposes but also stimulating the social and soft skills that nowadays are so demanded by the labour market (even more than knowledge itself in some cases).

It is hoped that this particular educational material will be another useful tool in teachers' and students' hands, to be utilised individually and at the collective level, accordingly, and contribute essentially to the efforts carried out in primary and secondary education, the educational world, and society to strengthen environmental responsibility of the citizens, having as a point of reference the young people who can become agents of change in the effort to transform society based on the principles of sustainability.



OBJECTIVES

ecoTHINGS project aims at:

1. Providing an innovative educational approach based on the STEAM philosophy that will grant pupils and students the chance to work with materials and technology they have never used so far.

2. Improving the target students' soft skills: communication, collaboration, critical thinking, assertiveness, creativity, and resilience, thus creating the conditions to implement the "learning to learn" practice.

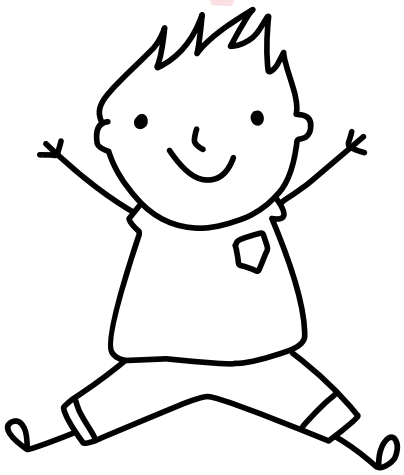
3. Raising the environmental awareness of secondary and primary school students, giving them the possibility to design and implement pilot projects aimed at reducing the impact of our daily lives on climate change.

4. Testing cutting-edge pedagogical approaches by merging Vygotsky's Theory of Social Learning with Gardner's Multiple Intelligences Theory.

5. Providing implementation guidelines that will include both the technological and pedagogical aspects, in order to ensure replicability, improve the digital skills of the students involved by utilising video editing and website back-end usage.

6. Making all of the above available to students belonging to families at serious risk of social exclusion.

METHODOLOGY



Nowadays, climate change, world temperature rise (along with the sea level), unpredictable weather, droughts and species extinctions are undeniable realities, and we are literally getting past the point of no return, with ignorance being the main reason behind this dramatic situation. For this reason, we consider it most appropriate to start environmental education as soon as possible in public education, raising awareness about the effects of the interactions between the mankind and the planet, but also starting to work on possible solutions, thus fostering entrepreneurial attitude among the future professionals in the labour market. Now that science has cleared the path from all sorts of doubts surrounding climate change, it is the education system's responsibility to pass this knowledge to all students, including students coming from disadvantaged social backgrounds who have not been given the right stimuli to develop environmental awareness. Its mission, nonetheless, is not limited to raising awareness of the problems, but also to offer possible solutions, both in technological and practical terms.

EcoTHINGS is an innovative pedagogical solution that addresses the need for modernising education, increasing environmental awareness, and ensuring access to digital education for pupils and students at risk of social exclusion. It prioritises innovative practices based on digital frameworks, in line with the STEM approach to education, which provides a suitable field to increase students' motivation,

level of participation and engagement, communication, collaboration, proactivity, resilience, critical thinking, and creativity. The development of such "soft skills" represents an essential goal when it comes to developing high-quality education systems, due to the intrinsic value of those in the integrated development of students, but also due to the innovative companies' demands all over the world, which keep criticising the current education system, blaming it for not helping pupils and students develop the skills that they require in a highly competitive scenario.

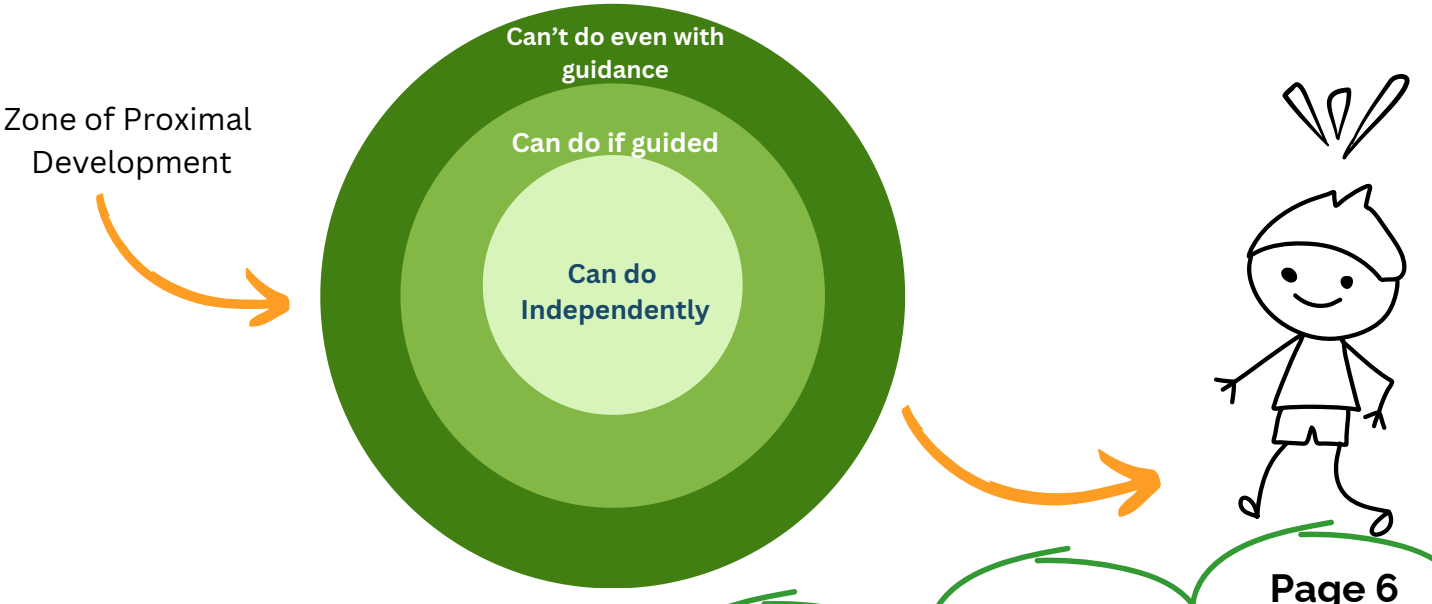
In this sense, EcoTHINGS comes to build an educational model based on "Learning Communities" following a set of educational actions aimed at social and educational transformation. The educational model merges the international scientific theories of the Social Learning Theory developed by Lev Vygotsky and the Multiple Intelligences Theory, developed by Howard Gardner. The Model highlights two key factors for learning in today's society: interactions and community participation to promote academic improvement for all students, rather than segregating some of them based on their learning levels or reducing their educational opportunities. It pursues overcoming school failure preventing absenteeism and early-school dropout and improving coexistence through greater inclusion, and social cohesion in very diverse contexts.

A) The Social Learning Theory by Lev Vygotsky

Social Learning Theory (SLT) is a theory that strives to explain the development of human cognitive and higher mental function. According to this theory, social elements, cultural elements and biological elements all affect the learning processes, and socio-cultural circumstances have a central role in cognitive development. Social Learning Theory states that individuals' development, thought and behaviour are influenced by the society and groups that they belong to (Rahmatirad, 2020).

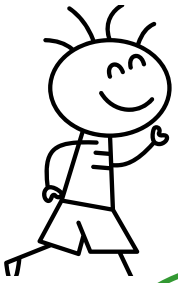
The theory believes that the development of higher mental functioning occurs by the following process: people internalise or regulate what they learn from social activities via mediation of symbolic tools. Learning happens in three different stages: cognitive, motoric, and sociocultural. Cognitive learning involves thinking about concepts and ideas; motoric learning involves doing things; and sociocultural learning involves interacting with others.

The central focus area of the Social Learning Theory of Vygotsky is the **Zone of Proximal Development** (ZPD) (Pathan et al., 2018).



It states that children learn in a zone and emphasizes the role and guided participation of an expert in their learning process and cognitive development. Levels of learning in ZPD can be listed as: what individuals can do alone, and what they can do with guidance or assistance from a member of the society who is capable (Rahmatirad, 2020). ZPD is defined as the distance between the actual development level of a child and level of potential development. Actual development level can be measured by independent problem-solving, whereas potential level of development can be measured by problem solving ability under adult guidance (e.g. teacher) or collaboration with more capable peers. (e.g. older students). The difference in learning between the two circumstances demonstrates that child learns actively and promptly in the company of a mentor, parent, more capable peer or a teacher (Pathan et al., 2018). Here, for instance, from a pedagogical point of view, Vygotsky suggests that teachers should match the requirement of the task with the capability of the child to finish the task, in other words match the current level of understanding of the child and the difficulty level of the task (Mahmoodi-Shahrebabaki, 2019).

According to the theory, all the resources, tools, instructions, and activities, that are used to support the learning process are referred to as **scaffolding**. It is the structure provided by other learners while learning a skill, following a series of steps - the scaffolds - to master it. More particularly, scaffolding will help the child to fulfil his cognitive potential, such as a situation that is created by a mentor, parent, expert or a capable peer to foster his or her skills and knowledge and boost his or her performance. By providing a scaffold, a child's entry to learning process is made successful and easy. This help may be reduced or stopped later on in order to make the learner more independent (Pathan et al., 2018).



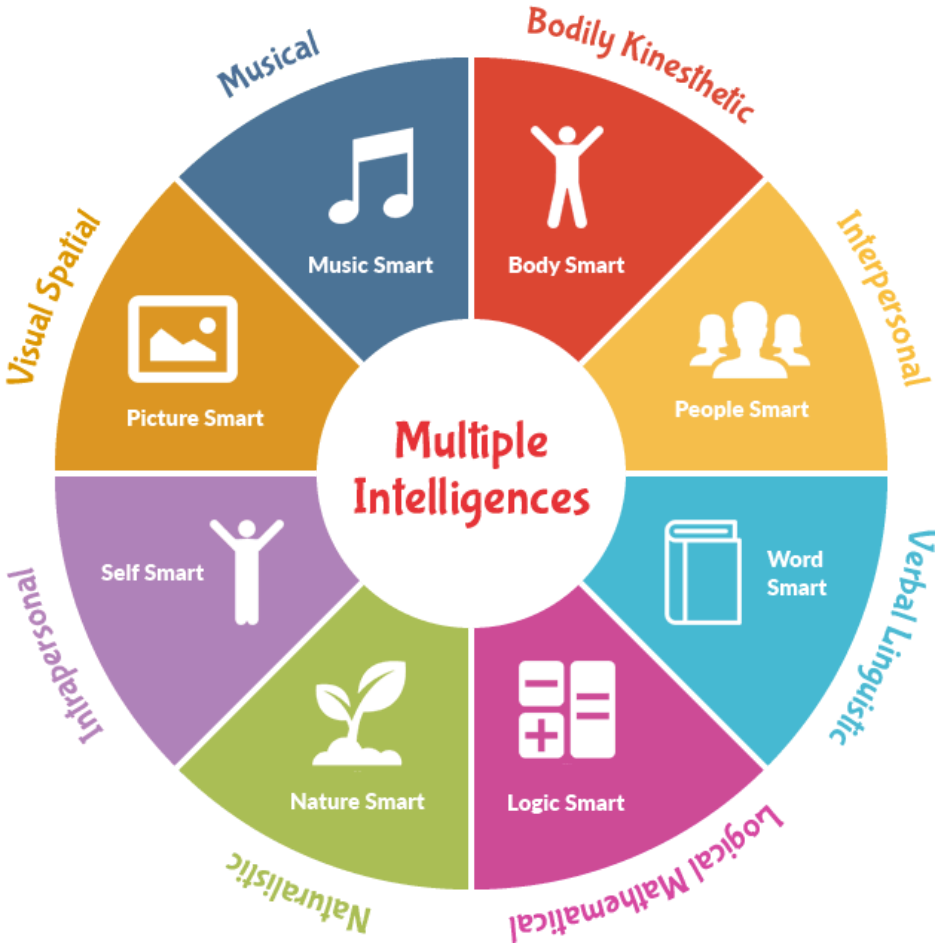
Furthermore, Vygotsky's theory leads to **internalisation** related to the cognitive development of the child on social and psychological planes, which is the process of learning from social to individual. Any function in a child's cultural development appears first on the social level (between people as an inter-psychological category), then on the psychological lavel (within the child, as an intra-psychological category). During development a child first interacts with his parent, mentor or teacher, and learns problem solving in their company, then the child becomes independent and performs tasks on his own (Pathan et al., 2018). Vygotsky rejects the idea of categorising children as intelligent and non-intelligent, instead he suggests that every child has a potential to develop with the help of others (Mahmoodi-Shahrebabaki, 2019).

For further reading please visit the website:
https://www.structural-learning.com/post/vygotskys-theory

Internalisation: the process of a child's process of learning from social to individual

B) Multiple Intelligences Theory by Howard Gardner

The Theory of Multiple Intelligences (MI theory) proposes that there are eight or more relatively autonomous intelligences in human beings. People rely on these intelligences to generate products or solve problems relevant to the societies they live in, and people may achieve this individually and corporately. These eight intelligences are (Davis et al., 2011):



https://additioapp.com/en/gardners-theory-of-multiple-intelligences/

1.Linguistic intelligence: the ability in oral and written work such as speeches and books

2.Logical-mathematical intelligence: the ability to solve abstract problems, make calculations and develop equations or proofs

3.Spatial intelligence: the ability to conceive large or small-scale spatial images

4.Musical intelligence: the ability to deal with different patterns of sounds

5.Bodily-kinesthetic intelligence: the ability to use one own's body to generate products or solve problems

6.Naturalistic intelligence: the ability to identify natural elements around us, such as types of plants, and animals (as this type of intelligence is less required today for the survival of human beings, the notion is retained to man-made objects in consumer societies)

7.Interpersonal intelligence: the ability to recognise the mood, desires motivations and intentions of other people around us

8.Intrapersonal intelligence: the ability to recognize mood, desires, motivation and intentions of one's own.

Multiple Intelligences theory sees intelligence not unitary in nature, but rather multiple, and poses that people may demonstrate varying levels of strengths and weaknesses for each of the eight intelligences. Individuals who are apt in one type of intelligence may or may not be apt in another type of intelligence. The theory refuses that an individual demonstrate 'no' capacity for a particular intelligence and states that all individuals possess the full range of intelligences, but may demonstrate low levels of a particular intelligence, and does not mean that an individual will show superior ability in one or more of the intelligences. The theory also states that intelligence is a combination of heritable potential and environmental factors, in other words skills can be developed in various ways by exposure to relevant experiences. For instance, someone born with a high intellectual potential in the bodily kinaesthetic sphere may achieve expertise in ballet performance with ease, whereas another person may need additional hours of practice; and in the end both performers may achieve excellence (Davis et al., 2011).

Ecothings project implemented the three theories (Social Learning, Multiple Intelligences and Constructionism) through Eco-technology courses and a students' mobility.

The Eco-technology courses took place in Valencia (Spain) and Kalkan (Turkey) during the school years 2022/2023 and 2023/2024. The Spanish pupils belong to Roma social groups at risk of social exclusion, while the Turkish students face geographical barriers. During the courses the Spanish and Turkish teachers organised workspaces characterised by high-tech learning material (3D design and printing; block-programming software; domotics hardware) and collaborative learning. The students worked in groups (4-5 students per group) and were asked to deliver specific results in the given areas (3D crafts; code; hardware connections) in a participative and cooperative way.

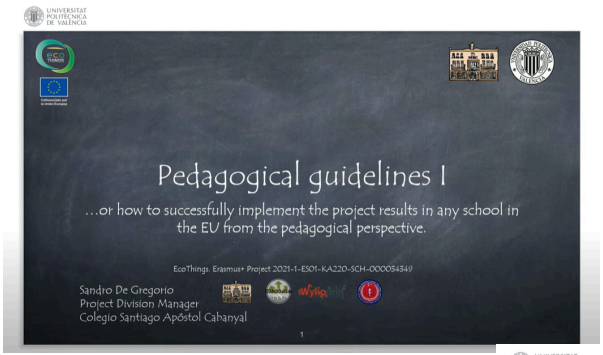
The children learnt from each other (in accordance with the Social Learning Theory); they had to develop different skills depending on the task (in accordance with the Multiple Intelligences Theory) and had to deliver an external physical or digital output (in line with Constructionism). In the case of the Spanish school, this scheme was put in place also through a different pedagogical framework, involving Engineering University students as leaders in each working group, with the aim to achieve even more ambitious goals from the technological point of view. Such a workflow was implemented via six special learning sessions during the 2023/2024 school year.

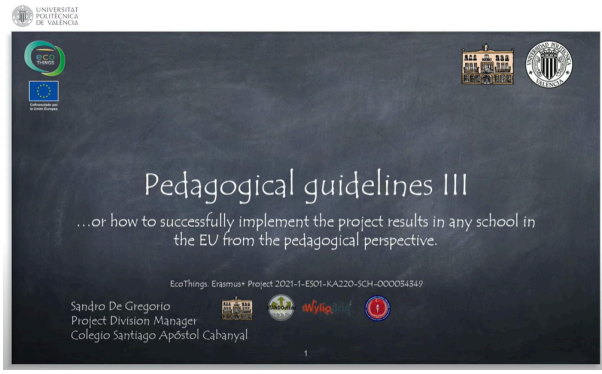
Nonetheless, the culmination of the pedagogical aims of the project was undoubtedly the students' mobility carried out in April 2024, which involved six Turkish secondary school students and 18 Spanish primary school pupils. Three groups formed by two Turkish students and six Spanish pupils worked on different aspects of a smart house to be built in five days. One group worked on the kitchen, one on the living room and one on the bedroom. Each room had a different set of sensors, code and 3D-printed objects (sofa, bed, chairs, stove, fireplace etc.). The Turkish students were assigned the role of group leaders, both the technical point of view and the pedagogical one.

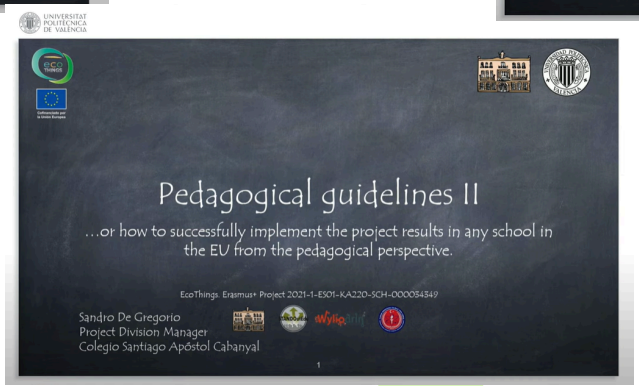
The initiative had a double challenge: on the one side the Turkish students were teachers for a whole week; on the other side, the Spanish pupils from disadvantaged backgrounds were supposed to acquire specific hi-tech skills from "more capable peers" within their Zone of Proximal Development.
The methodology proved successful as all the three groups delivered the requested output and a complete, fully operative smart house was set up.

It is important to highlight the increasing difficulty in terms of teaching-learning mechanisms throughout the two school years: first the Spanish children were supervised by teachers, then by University students and finally by secondary school students; similarly, the Turkish students first worked in groups as learners, then they worked in pairs as teachers during the mobility in Spain.
Finally, the project was conceived from the first step as a tool to foster social inclusion for children who face different types of educational barriers. It gave the children the opportunity to experiment with hardware and software that are not part of their corresponding curriculum, thus reducing the technological gap with the mainstream peers that skyrocketed during the COVID pandemic.

PEDAGOGOCAL VIDEOS:







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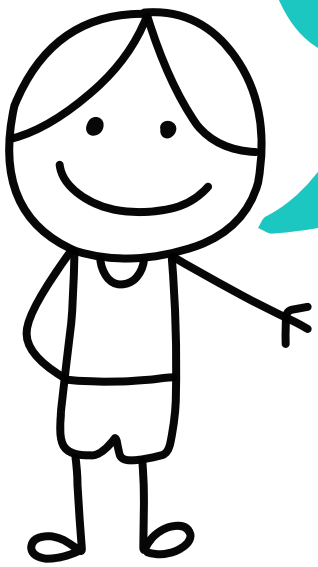
SMART HOUSE AND ECOLOGICAL CONSIDERATIONS

A) HUMAN IMPACT ON THE URBAN ENVIRONMENT



Global warming and climate change due to greenhouse gas emissions are becoming a serious challenge that the world is currently facing. Due to global urbanisation, over half of all people live in cities. Cities are major contributors to climate change since they are the primary producers of greenhouse gas emissions from urban activity. The generation of heat and electricity produces 25% of the greenhouse gas emissions worldwide. Therefore, it is imperative to implement energy-saving strategies to lower greenhouse gas emissions in urban areas. Energy-efficient measures in cities include, nowadays, smart technologies to make cities more sensitive to the environment in terms of energy consumption.

DID YOU KNOW THAT...

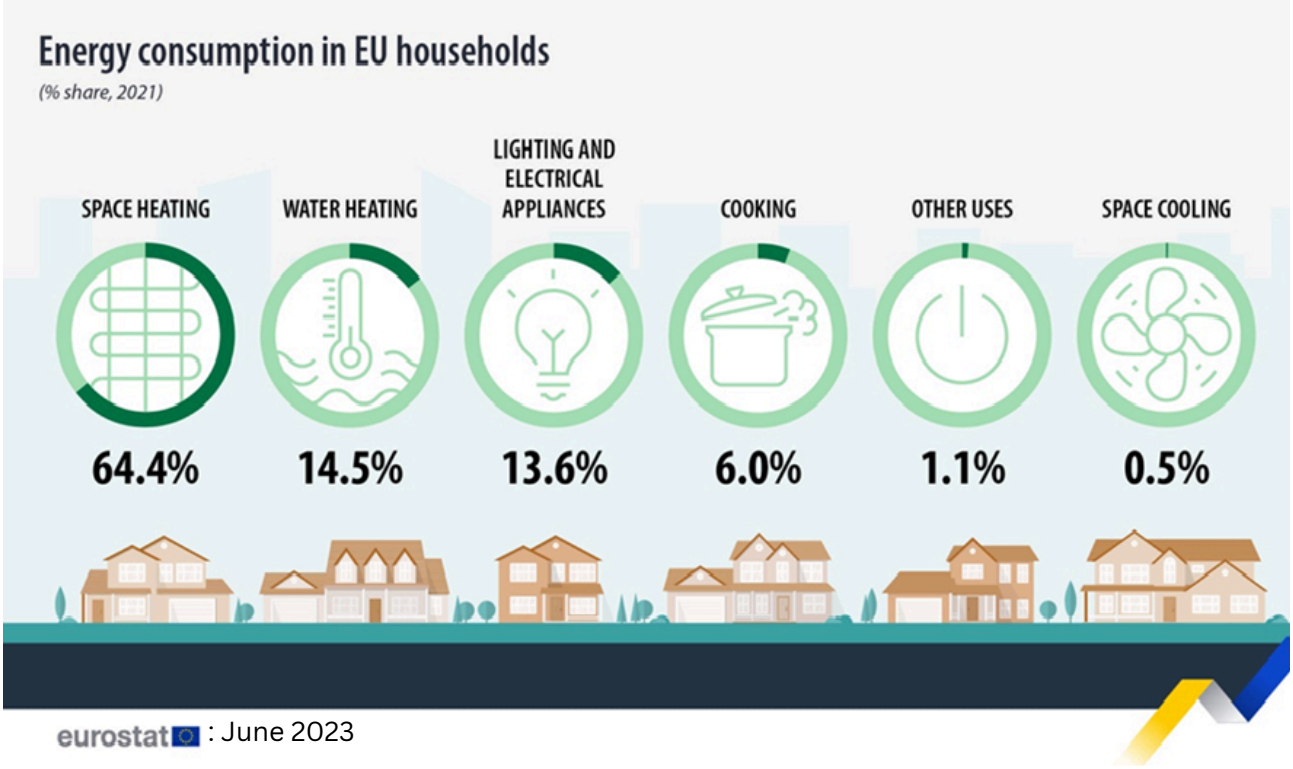
The main use of energy by households in the EU in 2021 was for heating their homes (64.4% of final energy consumption in the residential sector), with renewables accounting for more than a quarter (27%) of EU households space heating consumption.

In 2021, natural gas accounted for 33.5% of the EU final energy consumption in households, electricity for 24.6%, renewables and wastes for 21.2% and oil&petroleum products for 9.5%.

In 2021, households represented 27% of final energy consumption, or 18.6% of gross inland energy consumption, in the EU.

Eurostat, June 2023

The following Infographic gives a clear picture of the energy use of households for various purposes: space and water heating, space cooling, cooking, lighting and electrical appliances and other end-uses (mainly covering uses of energy by households outside the dwellings themselves).



Internet of Things (IoT) have provided novel solutions to the environmental problems caused by urbanisation. Sustainable development and technological concepts transform the cities into smart through making homes smart, since approximately 40% of total annual anthropogenic greenhouse emissions come from residential buildings. They play a key role in solving the city-related energy and GHG emissions problems. Actions focused on smart technologies lead at reducing building-related energy consumption and emissions.

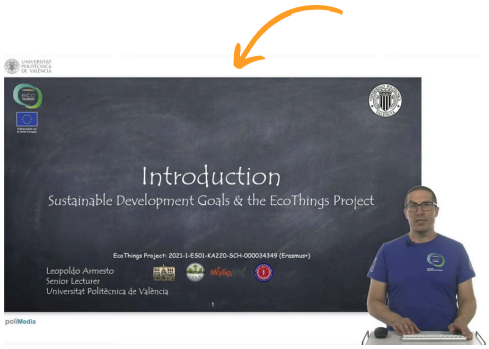
This is where the notion of the 'smart home' comes to the surface. The smart home integrates the home services into a common communication system, increasing its functionality and flexibility

to operate economically, safely, and comfortably. It assists the inhabitants to live independently with the help of technology through home automation, A smart home is based on the idea of integrating intelligent technologies into residential spaces with the purpose of increasing energy efficiency and inhabitants quality of life (Emekci, 2022).

The main areas of a smart home are air quality, indoor climate monitoring and temperature surveillance, heating, air, ventilation, lighting, and water heating control to minimize energy consumption. A smart home aims at minimising the operational cost of the building without sacrificing the comfort of the household. Therefore, it is wise to start with homes to achieve making cities smart and sustainable. Smart homes are the most important component contributing to the transition of the world's cities to a low-carbon energy system. It is worth mentioning that only one single smart home cannot make any difference in reducing the city's energy consumption, but by applying smart technologies to all homes can imply high rates of energy savings in the city (i.e. through smart grids) (Mohanty, 2016; Wang & Moriarty, 2018).

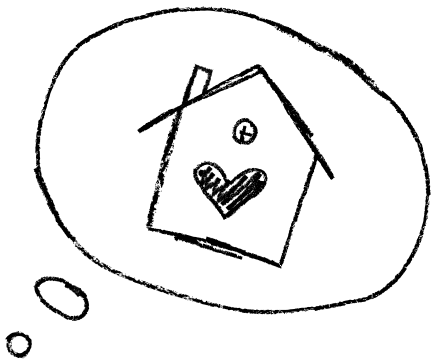
Consequently, energy consumption and greenhouse gas emissions in urban environments can be reduced by making houses -that have the largest share in cities' energy consumption and greenhouse gas emission - smart, in this way a strong step can be taken towards achieving the UN 17 Sustainable Development Goals for a better future for ALL.

4 B) SMART HOUSE: CONNECTION WITH THE 17 SUSTAINABLE DEVELOPMENT GOALS



EcoTHINGS project introduces eco-technology in schools to engage young people - especially those at risk of exclusion - with environmental issues to increase their environmental awareness through hands-on, interactive, collaborative activities in the frames of STEAM education. A Smart House was built in order to develop an Internet of Things prototype aimed at students at risk of social exclusion.

The proposed solution has been designed considering the UN 17 Sustainable Development Goals (17 SDGs) aimed to be reached by 2030. It mimics real existing passive houses and existing energy-saving systems. Based on the 17 SDGs, though, the passive house concept goes beyond energy-saving aims. The International Passive House Association (2021) identifies 8 relevant indicators of how a passive house aligns and contributes to the SDGs:



- Health and wellbeing
- Economy and job creation
- Social housing and energy poverty
- Education
- Resilient and innovative buildings
- Sustainable consumption and production, International cooperation
- Climate change protection and accountability

A careful study of the 17 SDGs led to the conclusion that the Passive House is meaningfully influencing 10 SDGs, based on the above indicators as described by the Association. It contributes to:

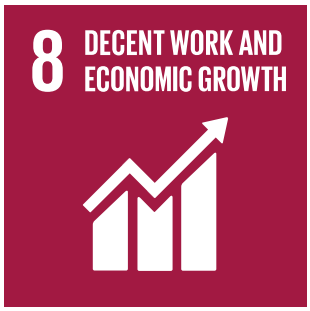
- Social housing: equal access to healthy and comfortable homes for the vulnerable
- Extremely low heating and cooling costs that aid in tackling fuel poverty
- Reduction of auxiliary costs in the home allowing saving money or used for other necessities
- Sustainable jobs for building professionals

- Healthy environment since modern life leads us to indoor-focused lives (i.e. in the office, at school, work from home). It offers high thermal comfort and high air quality
- Thermal envelope and mechanical ventilation: it filters incoming air to ensure external pollutants do not affect the fresh, internal air supply, thus reducing the rate of illnesses and respiratory issues (Rosemeier & Brimblecombe, 2017).

- Equal access and further learning opportunities for novices and experts
- Passive House training is available to a wide range of professionals in the construction chain
- Substantial grow of number of courses and training providers, increase of relevant skills for employability and entrepreneurship.

- Energy-efficiency
- Low fuel costs
- Integrating renewable energy sources and encouraging energy supply from renewable sources.
- Reducing the energy needs to low levels
- Increasing the share of clean renewable energy and localising the energy market.

- Energy efficiency which is a job-creating sector (McKinsey, 2020).
- Helping smaller, local job markets thrive and creating opportunities for small to medium enterprises.
- Investing in this sector on capacity building opportunities and combatting climate change while building resilient industries and buildings.



- Significant reduction of operating costs and emissions and supports the uptake of renewable energy.
- Time-testing resilience, resistance to mold and moisture damage
- Elimination of draughts and excessive heat losses because of its high level of insulation and airtight and thermal bridge-free design
- Innovation since it is closely linked with research and practices to develop innovative, cost-effective, sustainable building materials and solutions.

- As for health and wellbeing in urban areas, resilient and innovative buildings, sustainable consumption and production, economy and job creation, and climate change protection and accountability all play a role in making cities and human settlements safe, resilient, inclusive, and sustainable to unlock a more sustainable future for the people.

- Accomplishing a sustainable existing building stock
- A renovation wave of existing buildings which are highly energy-efficient one through exchanging components of the building as they reach the end of their lifecycle for high-quality passive house ones.
- Retrofitting which leads to reuse of existing building stock, thus reducing waste generation by preventing the need for new builds – a more sustainable production pattern
- Reducing operational energy demand, ensuring sustainable energy consumption.

- Combating climate change through its grounding to building physics and clear, scientific, performance-based criteria, to reduce energy demand and carbon emissions in order to reduce the energy footprint
- Reducing heating and cooling demand in retrofit projects, which is a major topic in existing, heavily built-up environments to prevent missed opportunities to fight climate change.

- Disseminating and increasing the international knowledge transfer and uptake of the passive house standards through networking at European and international levels.
- Creating a global network of architects, planners, suppliers, manufacturers, scientists and research partners, policymakers, property developers, training centres, to provide access education and improved awareness and policy uptake.

For further reading please follow the link
https://passipedia.org/basics/passive_house_and_the_sustainable_development_goals

C) THE SMART GREEN HOUSE: AN ECOLOGICAL SOLUTION

The smart green house provides for the needs of the residents while being environmentally friendly. Green homes and smart homes are frequently used synonymously. There is, however, a slight distinction between the two: Smart green homes place equal emphasis on using the newest technologies (SMART Technologies) to provide for the needs of the residents, while following the principles of sustainable development (ECO-FRIENDLY features and technologies) as green homes do to minimise human impact on the environment:

SMART Technologies

'Smart' was originally an acronym: Self-Monitoring, Analysis and Reporting Technology. Since, though, the word 'smart' means clever, it has also become a way to describe technology that can guide our behavior. Automation characterises smart technology, which can be programmed by the user to do something at a specific time or for a specific reason. Some devices can be controlled remotely through Wi-Fi or Bluetooth. Setting up smart technology home can reduce energy consumption and protect the environment at the same time.

Smart homes can choose to have smart speakers, lights, thermostats (i.e. automated heating and cooling), doorbells, or home hubs, voice control, digital security, and effortless entertainment. Smart technology can also extend to kitchen (i.e. intelligent appliances) or outdoor landscaping equipment (i.e. automatic irrigation). New innovations are continually evolving the specifics of a smart home. For further information please watch the video

https://www.youtube.com/watch?v=Br5aJa6MkBc

ECO-FRIENDLY Features & Technologies

Eco-friendly features and technologies reduce or completely cut out any damage done to the environment. When applied to the home, it means using eco-friendly construction materials, fewer resources, and reducing energy use:

- **Eco-friendly construction materials:**

Eco-friendly construction materials are the ones that do not affect the environment during manufacturing, use, or disposal and are easily recyclable. They greatly minimise carbon emissions and conserve energy, resulting in lower energy costs. They make the most efficient use of resources, generate the least amount of waste, and are safe for the environment and humans (**Link to PR1**).

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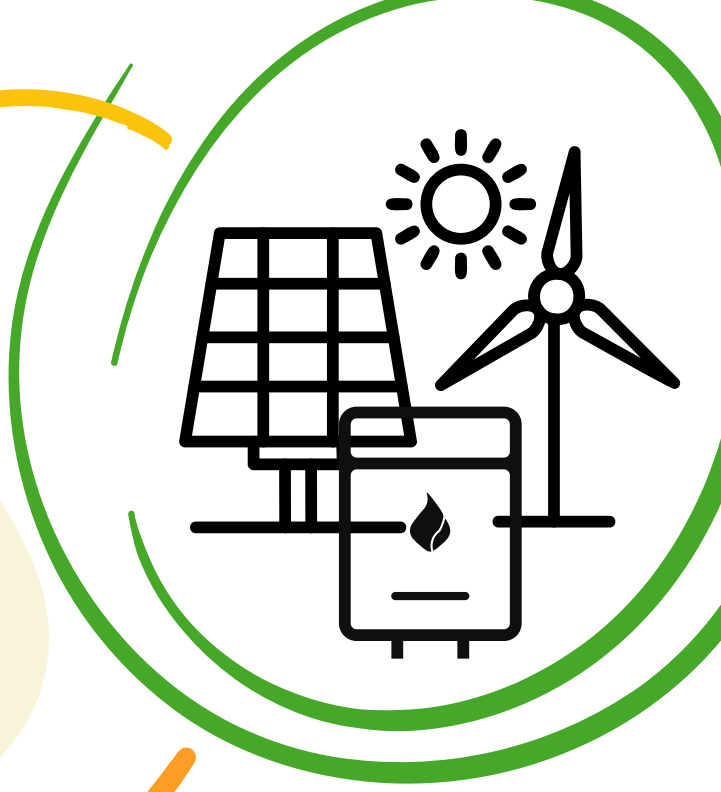


Renewable energy

It is produced by sources that replenish themselves naturally, such as wind, rain, tides, waves, sunlight, and geothermal heat. It is possible to use renewable energy to power our homes (i.e. wind turbines, solar panels, a biomass boiler, or a heat pump).

Biomass boilers

Biomass boilers are similar to gas boilers in that they use combustion to provide heating and hot water for our homes. However, they use sustainably-sourced wood pellets to produce this heat and must be emptied of ash every month to be put on a compost heap. Turning the wood into pellets reduces waste, and since the wood will have already absorbed carbon dioxide while it was a tree, it is also carbon neutral. Because of this, there is no net release of carbon dioxide into the atmosphere.

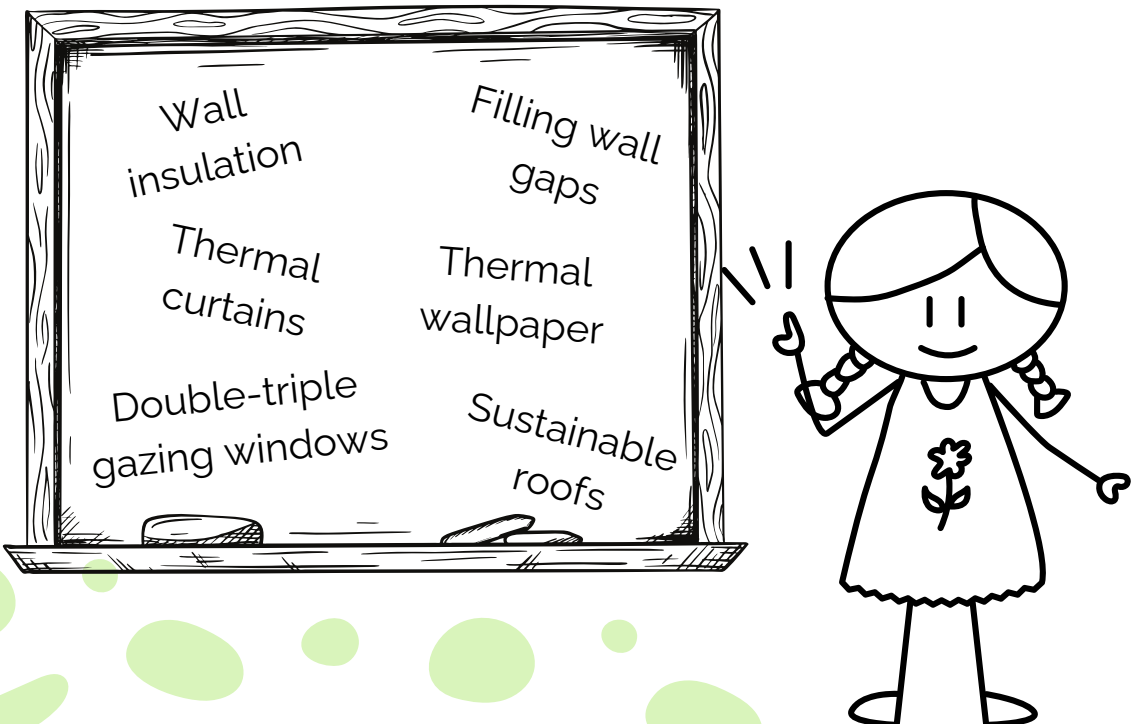
Heat pumps

The most common heat pumps are ground source heat pumps circulating water and antifreeze using a series of pipes, with heat from the ground absorbed into the fluid. This mixture passes through a heat exchanger and heat pump and can be used in radiators, underfloor heating or for hot water. The temperature below ground stays the same all year round, so we can rely on this method throughout every season.

- **Insulation:**

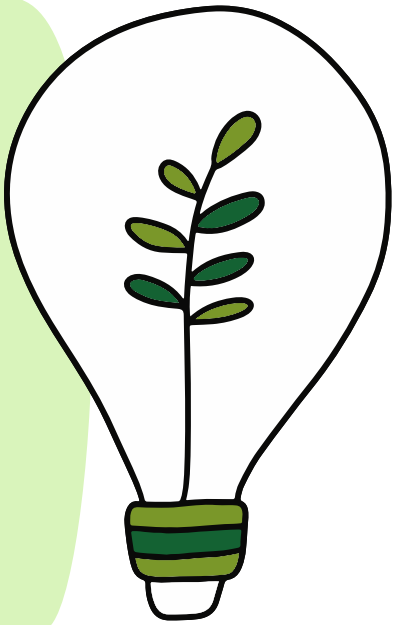
Insulation in a house is the most effective pathway to prevent losing heat unnecessarily, cutting carbon emissions and energy bills. Insulation could take place:

1. In the walls of the house through the use of non-toxic, renewable, and biodegradable alternatives to traditional insulation materials. Solid walls can be insulated either from the inside or from the outside. Alternative materials are cotton, cork, sheep wool, and recycled items like plastic, denim and newspaper.
2. New sustainable roof designs include technology that reflects heat and sunlight away, regulating the temperature of the house.
3. Double or triple-glazing windows can reduce heat loss, reducing condensation, and noise pollution is also eliminated.
4. Gaps in the house contribute to a great amount of energy loss. Filling these gaps can significantly contribute to the increase of warmth inside the house.
5. Using thermal wallpaper, also known as a thermal liner, made from a woven mix of wood fibres and textile fabrics, can be attached to the house walls.
6. Thermal curtains can create a pocket of air between the curtain and the window to prevent warmth from escaping the room.



Light bulbs:

Swap old light bulbs for LEDs because they are more affordable than they used to be, and they require very little energy to work. Unlike traditional energy-saving bulbs, they are bright as soon as you switch them on. LED bulbs use 90% less energy than traditional bulbs and last up to 30 years



Water conservation:

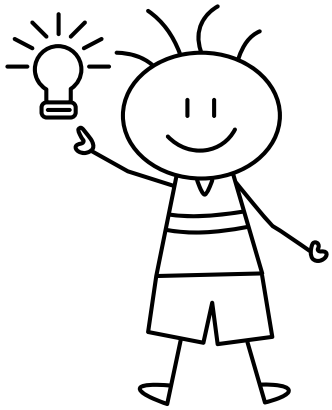
Installing a harvesting system to collect the rainwater from the roof, filtered, and stored in a tank underground the house, decreases reliance on water from the mains. The collected water can be used for washing the car, watering the garden, or even top up the toilet cistern.

Water-saving devices can be changed to low-flow aerators in taps or a low-flow showerhead can save a significant amount of water.

Energy-efficient appliances:

Buy efficient models of domestic appliances (dishwashers, washing machines, fridges, ovens and hobs) having the Energy Star label and good green credentials and running costs

HOW TO CONSTRUCT A SMART HOUSE: A STEP BY STEP GUIDE



STEP 1

PRELIMINARY IDEAS

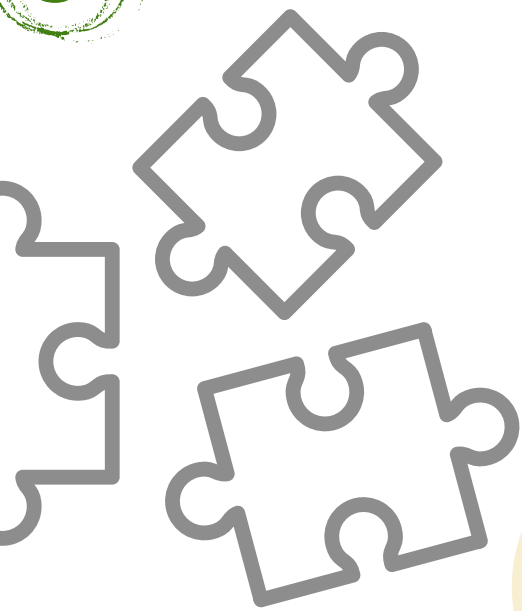
STEP 2

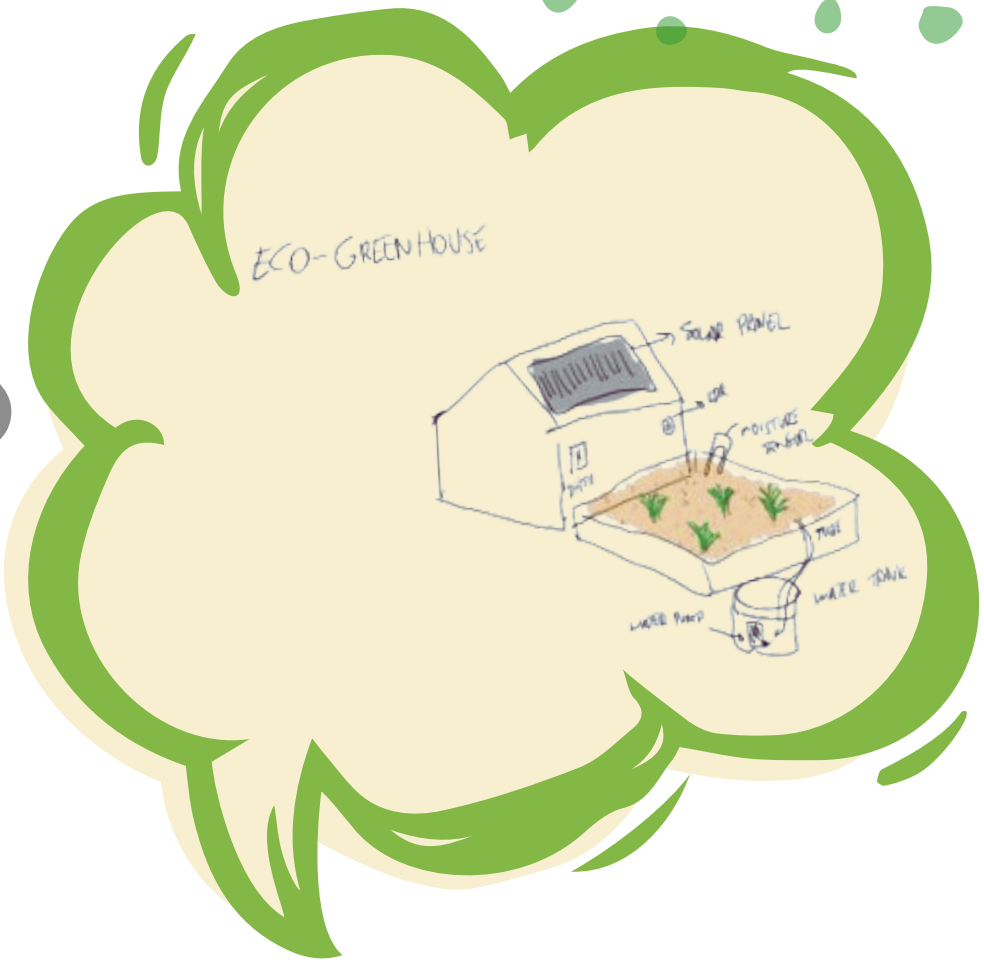
HOUSE DESCRIPTION AND DESIGN

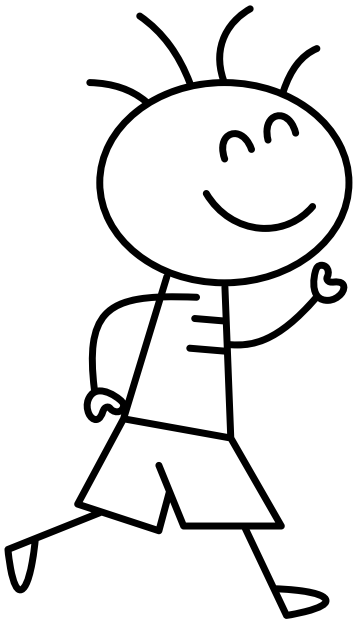
STEP 3

BUILDING THE SMART HOUSE

5







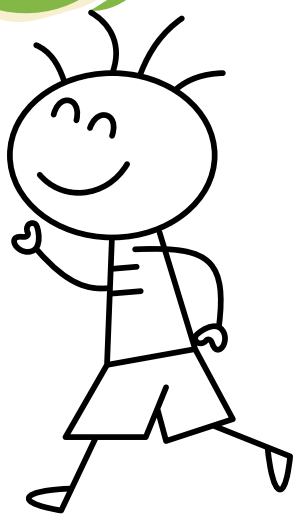
STEP 1 STEP 2 STEP 3

PRELIMINARY IDEAS

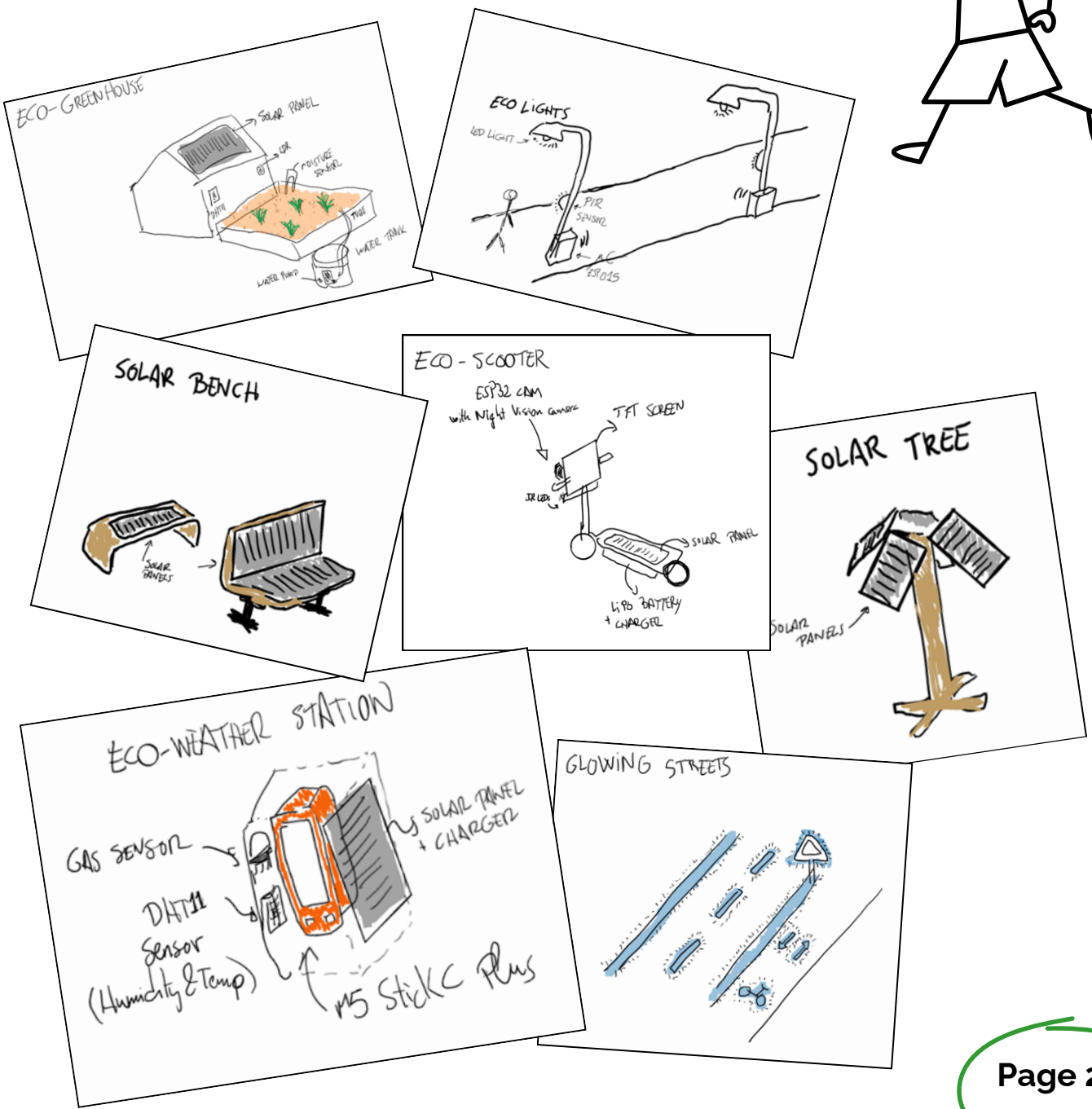
STEP 1:

Preliminary ideas:

HOW TO CONSTRUCT A SMART HOUSE: A STEP BY STEP GUIDE

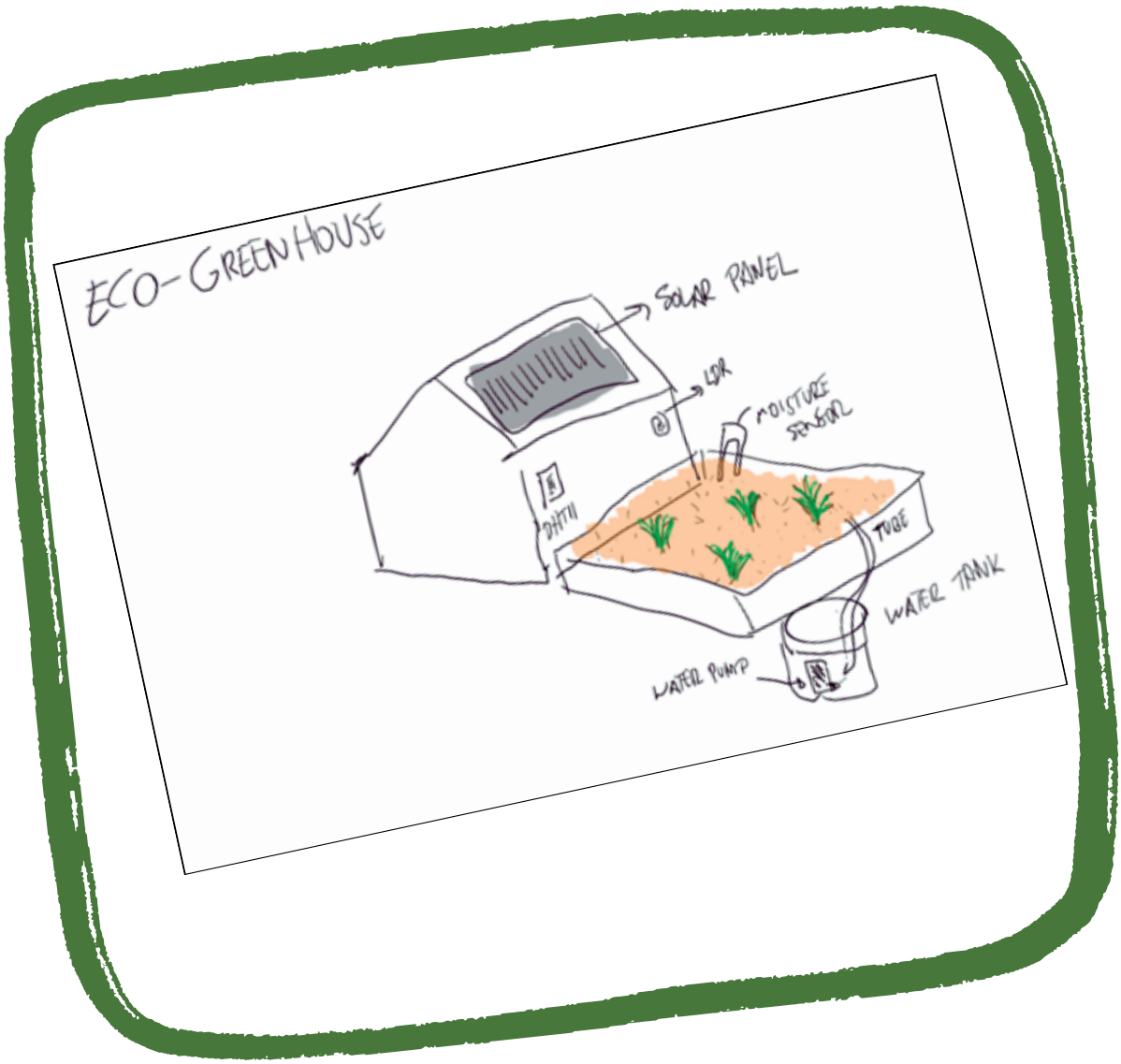


Explore ideas in a brainstorming preliminary phase. Discuss the idea of developing a smart-house taking into account ecological aspects during the design phase. Additional "eco-things" could be implemented closely related with the smart-house., such as:



STEP 1:

Eco-greenhouse: Using a temperature sensor (DHT11 or any similar one), a light sensor (LDR) and a moisture sensor (soil humidity) we could grow plants for a smart eco-greenhouse. A water pump would drain water into the greenhouse when needed. In the end, most of these ideas were not implemented because the use of water with wood-made and/or cardboard parts to build the house walls could be messy, but the fact of using a temperature sensor together with a light sensor, was useful to integrate them into the smart house.



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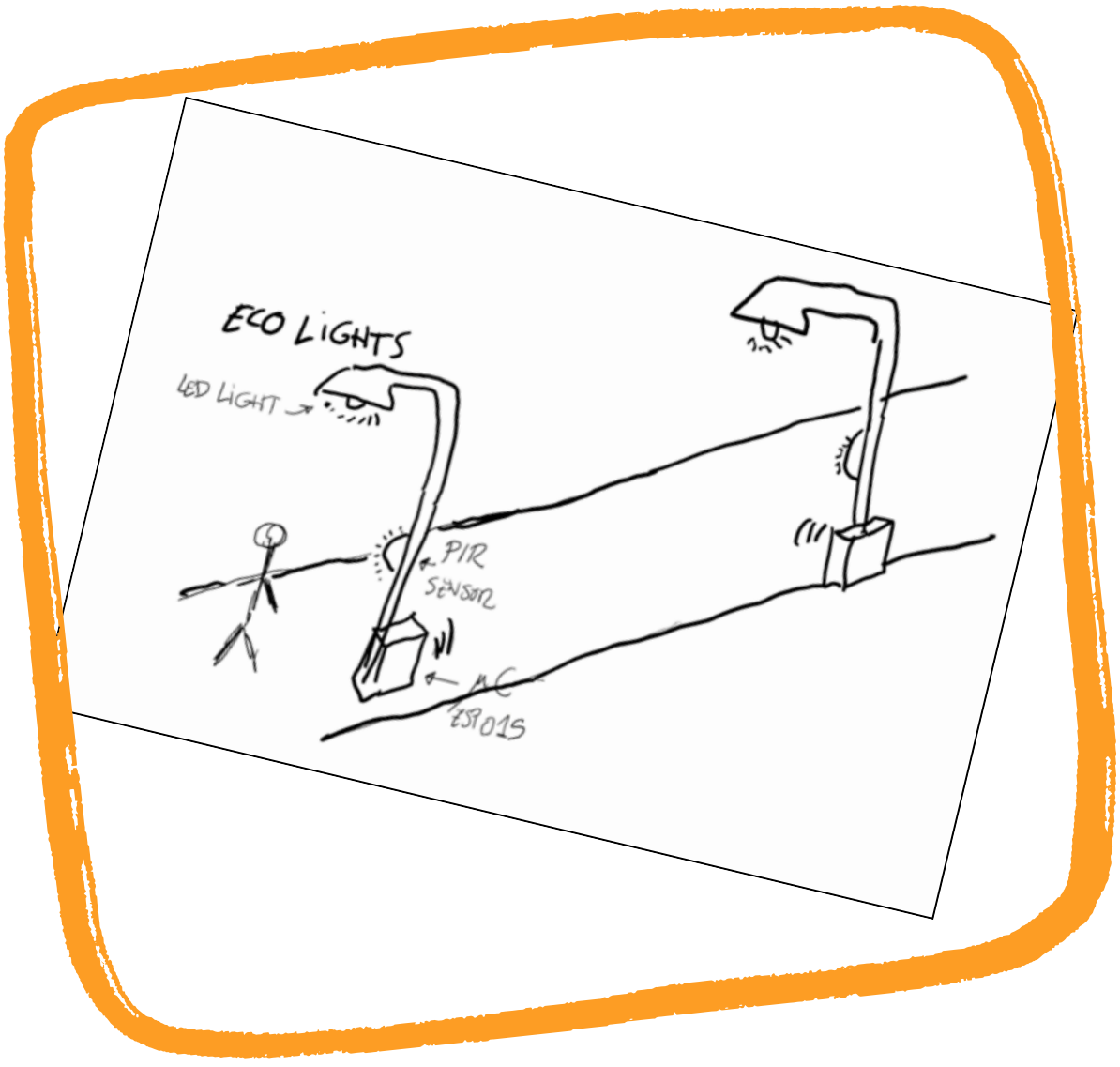
STEP 1:

Eco-lights: The idea behind of eco-lights was to save energy by detecting the presence or absence of people walking on the street. Using a PIR sensor, we could detect the presence of people on the street and decide to switch on the lights meanwhile its been detected (and likely during a short amount of time just before and after). Lights could be connected over internet, so detection could actually affect to several lights in order to cover a wider area. Part of these ideas were finally included in the smart-house as part of the bedroom proposed solution as it will be described later on.



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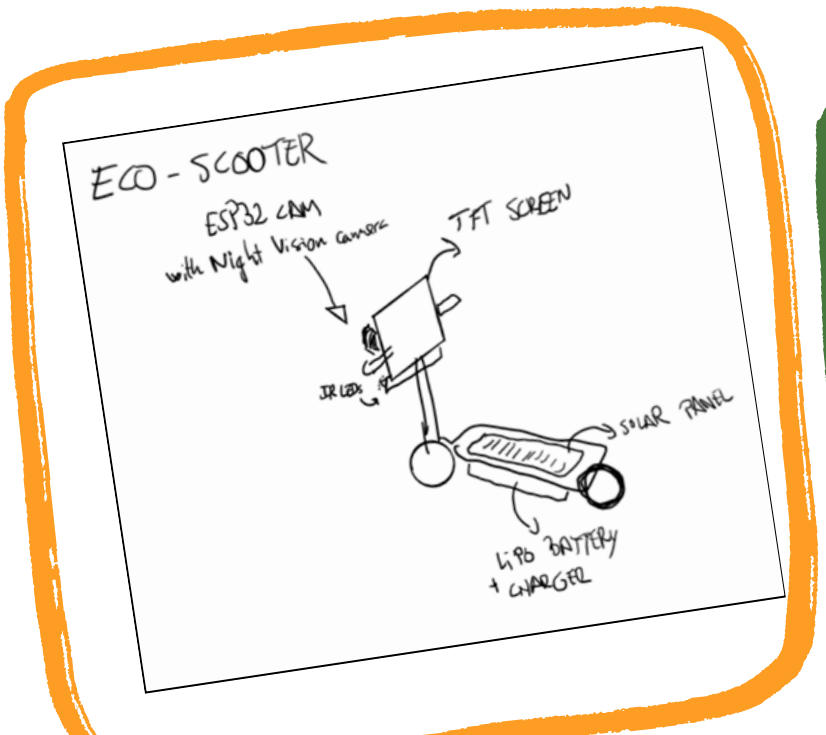
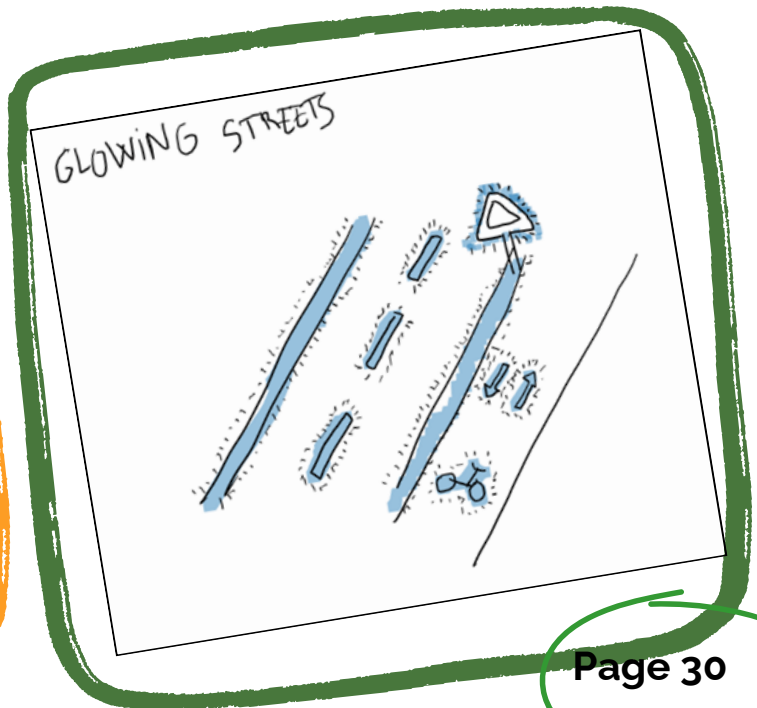
STEP 1:

Eco-scooter and glowing streets: To contribute to mobility solutions aimed to low environment impact, we thought that might be a good idea to implement an electrical scooter (low-scale prototype) that included a ESP32 CAM with a night vision camera and a TFT Screen. The idea was to show on the TFT screen the camera image. Our "vision" was that, not just the house, but the city had to go into "dark mode" to reduce light pollution. So the idea is that scooter could use infrared LEDs and a night vision camera to display images on the TFT screen with high sensitivity. In addition to this, we considered the idea of using glowing painting so emphasized the traffic signs and horizontal signs.

In the end, we decided to use the ESP32 cam for a future version that can be integrated in the smart house. The main reason is that despite of the fact that ESP32 cam was operative, we found a lot of issues that caused technical difficulties and we considered that it was too complex to be implemented at schools (particularly primary schools). Besides that, our prototype includes the possibility to include a ESP32 as a smart home safety system (i.e.: motion detector). We also decided to include the TFT screen as part of the smart house to be able to display variables of interest.





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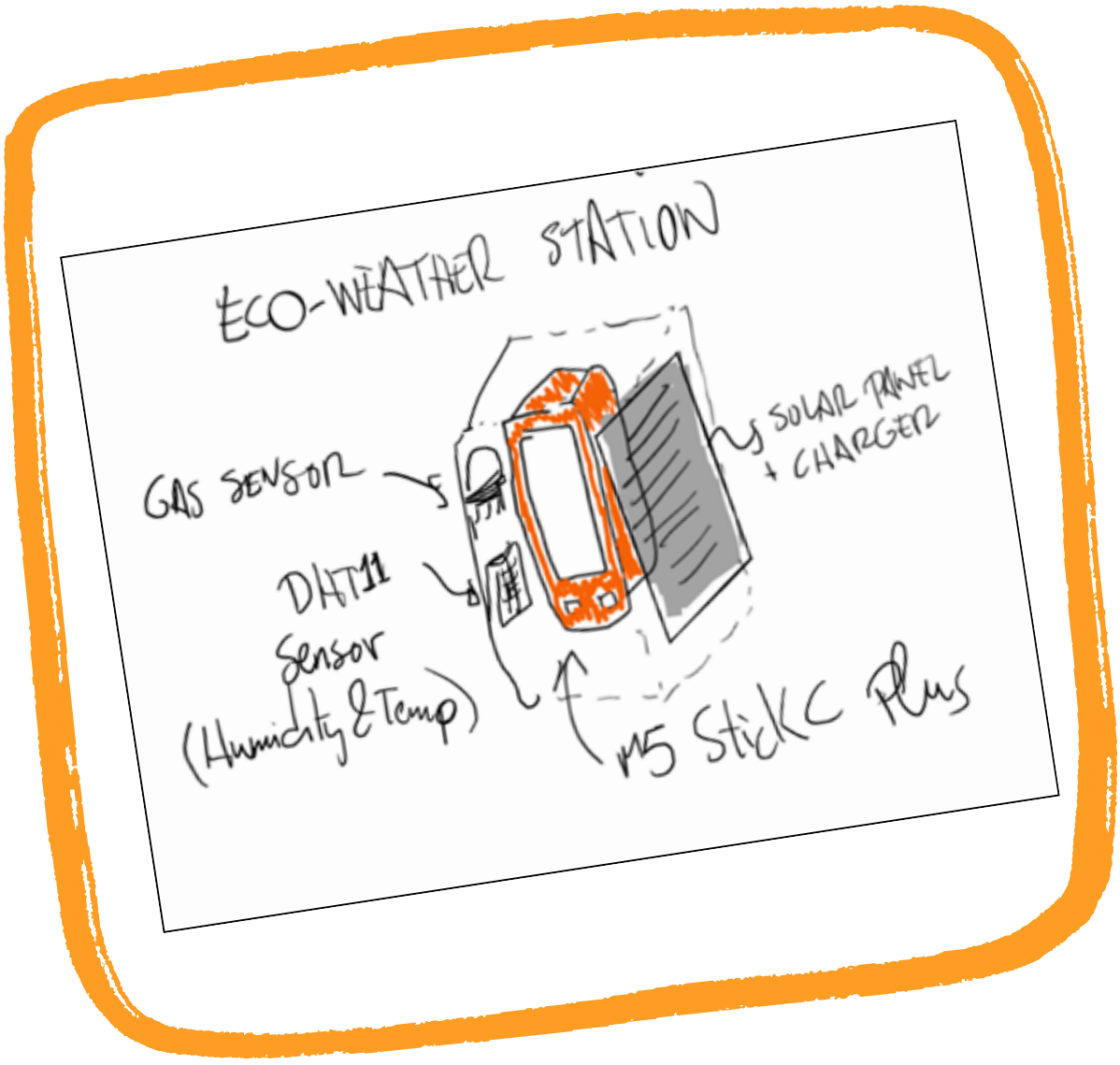
STEP 1:

Eco-weather station: The idea behind the eco-weather station was to monitor temperature and air-pollution and display the information on a M5 stickC Plus device that included a small embedded screen. Using a Gas sensor (MQx), someone can measure air pollution, while the DHT11 sensor could be used to measure temperature and humidity. In the end, these ideas were transformed and integrated as part of the smart house. The difference is that instead of measuring temperature, we decided to measure noise (with a MIC), because external temperature could be obtained via web services. Also, instead of measuring air pollution, we decided to detect smoke in the house to prevent from fire.



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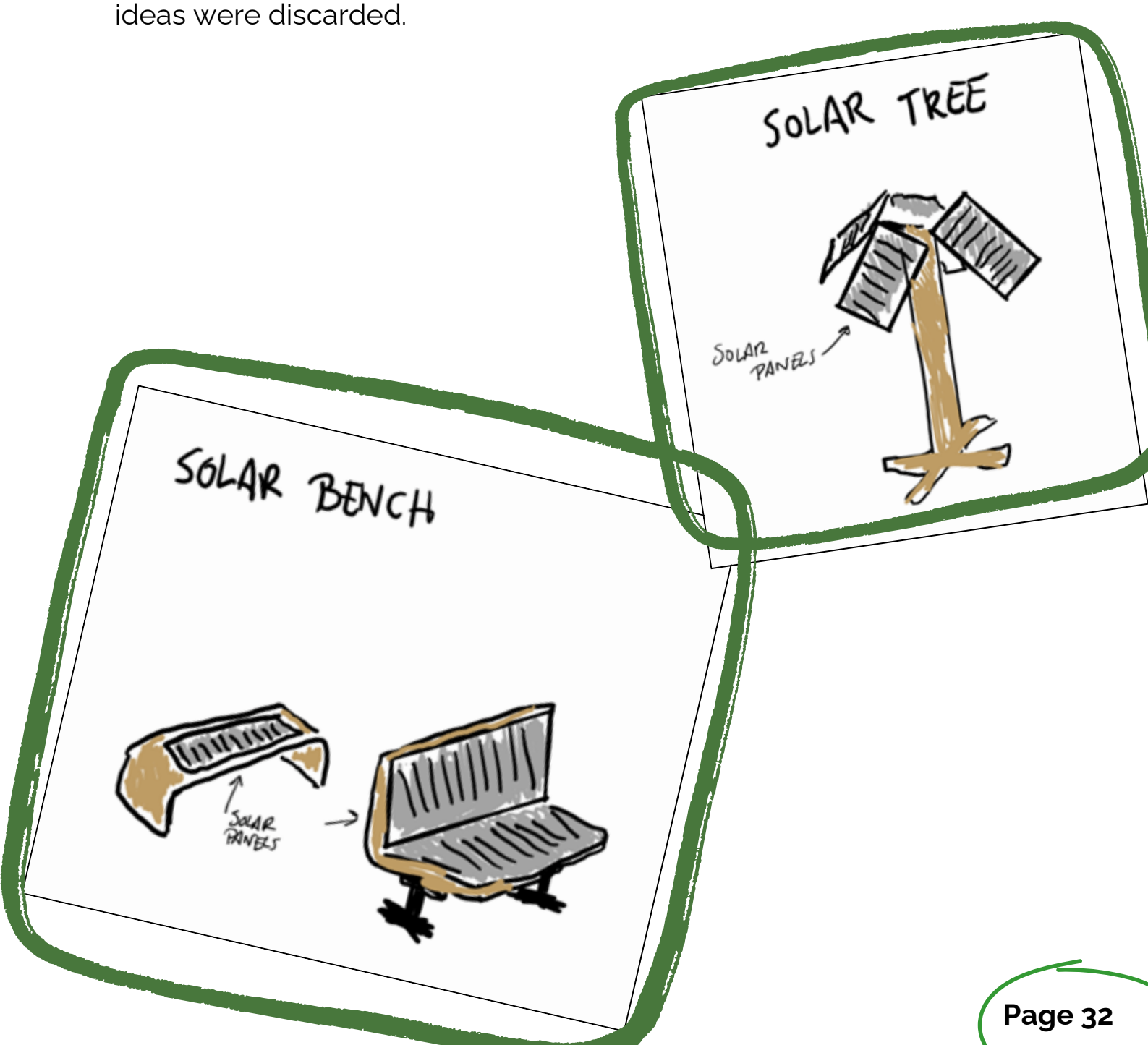
STEP 1:

Solar tree and solar benches: These two ideas we indeed quite promising, and as you could see from all of our previous ideas, all of them include solar panels. So the idea was that every "eco-thing" was environmentally friendly sustained with its own energy source, but apart from that, we thought that it might be a good idea to include additional sources of energy integrated in the urban design of parks and green areas. The problem is that after some tests, the solar panels used for low-cost solutions did not seem to provide enough energy to even charge a LiPo battery, so in the end, these ideas were discarded.



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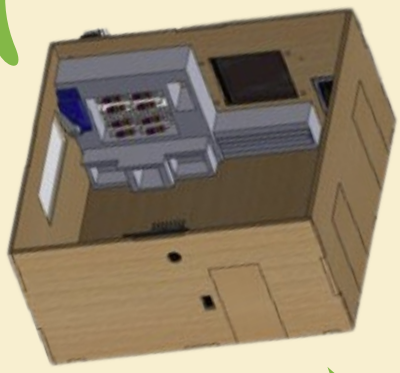
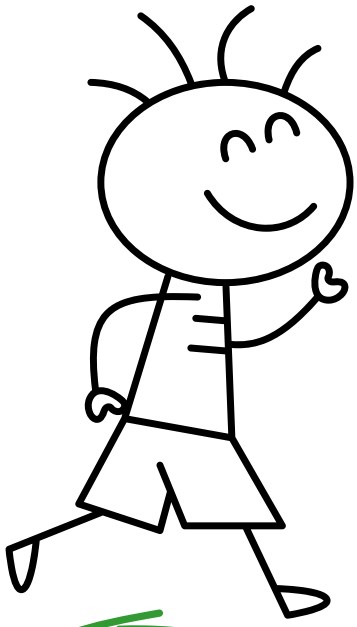




STEP 1

STEP 2

STEP 3

HOUSE DESCRIPTION AND DESIGN

STEP 2:

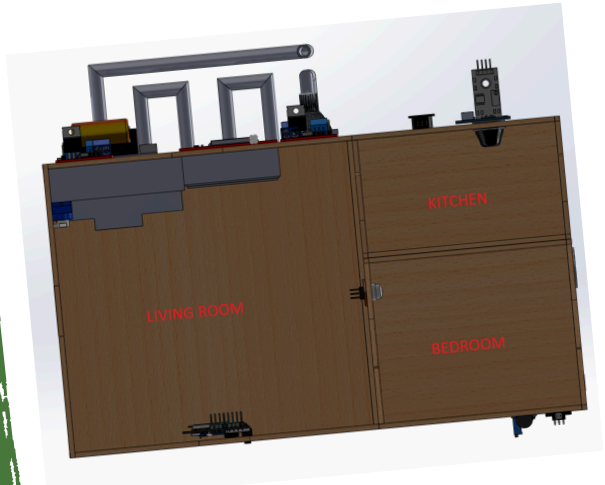
EcoThings. Intelligent House. Description

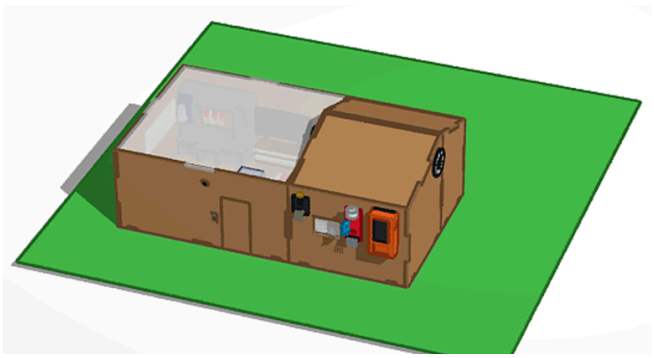
House description and design:

A) House layout:

The smart house includes a living room, a bedroom and a kitchen. The electronics are placed on the outside of the house - on the rear part. All three rooms are designed to be modular, which means that they can be separated and only one of them can be implemented if so wished. The house can be manufactured using laser cutting or 3D printing technologies. These two technologies are accessible to many schools (either because they have their own means or because outsourcing a manufacturing service is affordable).

Sensors and actuators are placed in and around the house so that they are integrated in furniture, kitchen-ware or room-ware, to actually have the appearance of a house.

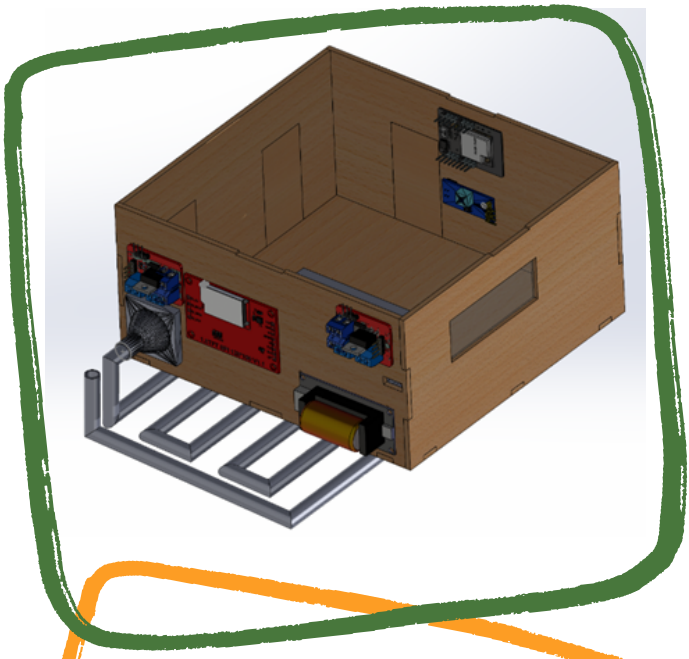


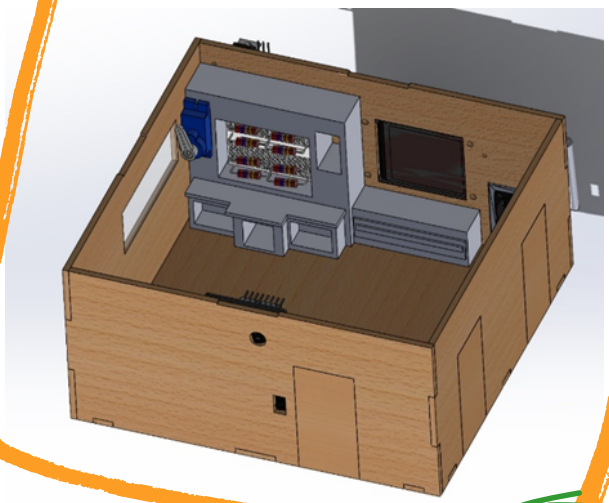


B) Living Room:

The living room is used to teach the importance of energy saving and it is inspired by passive houses. Depending on the inside/indoor/room temperature, humidity, and outside temperature, it can be programmed to either produce heat using a pack of resistors (inside the chimney) or to produce air ventilation using a fan (double direction control to push-in or push-out air into the room). Air ventilation can be used to warm or cool down the room due to the fact that air will be conducted underground (mimicking real passive house solutions), since underground temperature is more stable than outside temperature. In the prototype, we obviously do not expect to work exactly as a passive house, but similar principles are implemented in the end.

The living room has a temperature sensor (NTC sensor) to measure the room temperature. This is an analog sensor that can be connected to any of the analog input pins. In addition to this sensor, the living room uses a set of resistors to heat the room. Resistors are, indeed a set of 12 standard 0.5W resistors in a parallel configuration, so each of them dissipates a small amount of energy, but all together they work as an actual heater. These resistors require a high current demand so actual current will be driven by a MOSFET connected to any digital output pin.

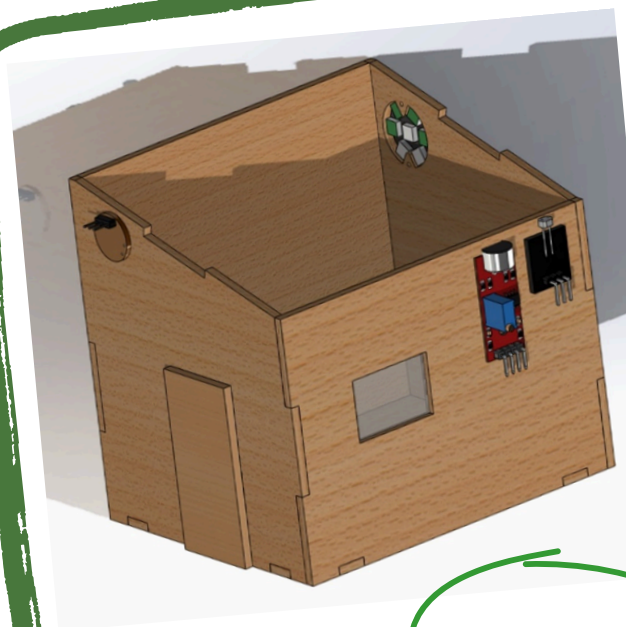




To cool down the temperature (or even warm up the room if the external temperature is higher than the room temperature), we can use a fan, which is a brushed DC motor that can be driven with another MOSFET. Eventually, we might prefer to cool down the temperature just by simply opening a window with a servo motor. Both the resistors and the servo are integrated into a chimney/library as part of the house decoration. The living room also includes a TFT Screen to display the smart house status and it has the appearance of a TV screen. This is a full-featured RGB screen that can be used for many purposes.
Printable version of the designed living room is available in TinkerCAD:
https://www.tinkercad.com/things/4YHhi7fpkSa

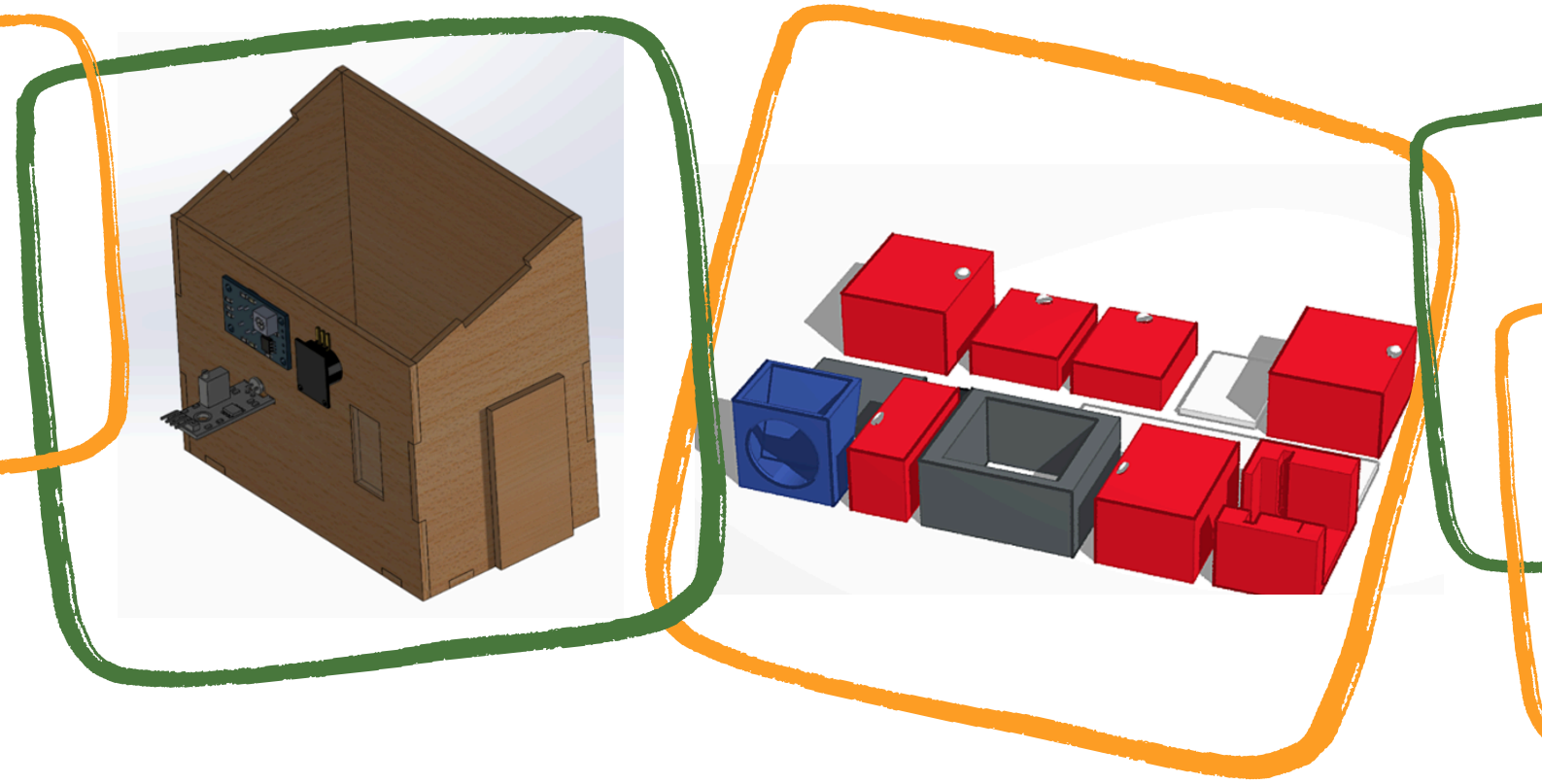
C) Bedroom:

With bedroom light control, based on current daylight and the presence of people in the room and external light (with a LDR), energy can be saved and also noise pollution can be reduced using a sound (mic) sensor and a servo (to open/close the window). The bedroom includes a RGB LED strip so that the colour and brightness of the light of the bedroom can change accordingly to the user needs. With all these sensors, energy is saved by opening the window (with a servo) and switching on/off the lights of the RGB LEDs (the mic can be used to determine to close the window and switch on lights even if there's light due to an increase of external noise). Also, depending on the weather, we can determine to open or close the window (i.e. it will stay closed on windy and rainy days).



D) Kitchen:

The kitchen is equipped with gas and flame sensors that can detect smoke and fire. It also includes a buzzer for alarm beeping and a servo to open or close the window in case of fire or smoke. Using these two sensors we can warn with the buzzer and send an email to warn the owner and automatically close the windows.



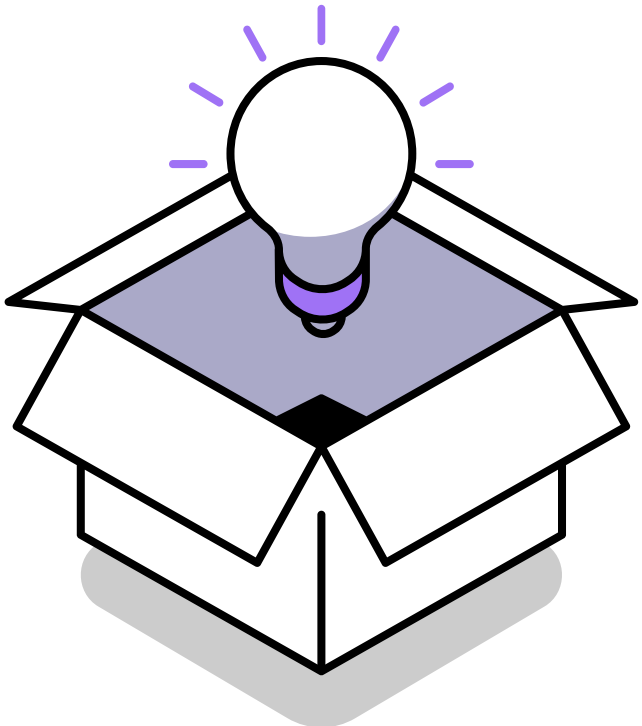
E) Other ideas:

- Intelligent main door opening based on a smart camera recording a video when a person rings the bell. The user can decide whether or not to open the door based on the stored image.

- A pollution station to be used to monitor the air quality as well as the noise pollution outside the house. This will be useful when deciding to open the windows of the house for natural ventilation of the main room and bedroom (independently from the temperature control).

- Solar, wind and kinetic energy saving: all saved energy will be monitored and displayed, proving an indication of the total amount of saved energy so far.

- Water-saving energy in the bathroom. The idea is to use a water filtering system based on a sand filter so that clean water can be stored to be used when bathing. Thus, when needed, when a button is pushed, a small water pump will allow bathing.



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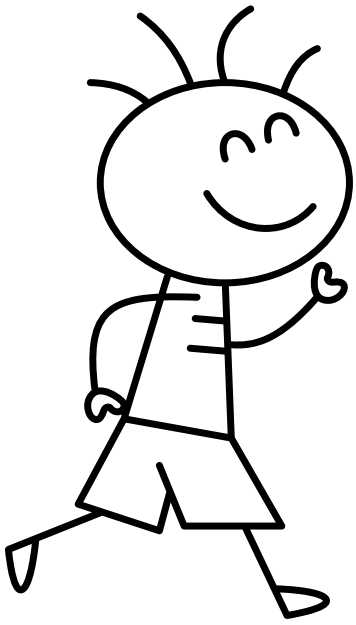

STEP 1

STEP 2

STEP 3

BUILDING THE SMART HOUSE

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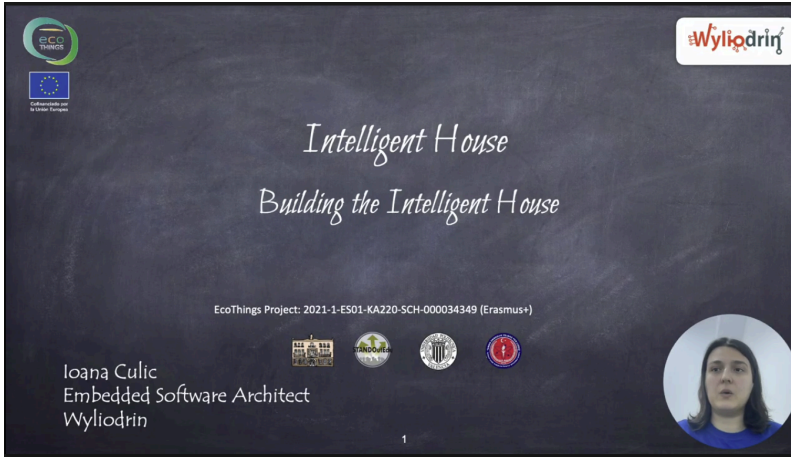
STEP 3:



Building the smart house:

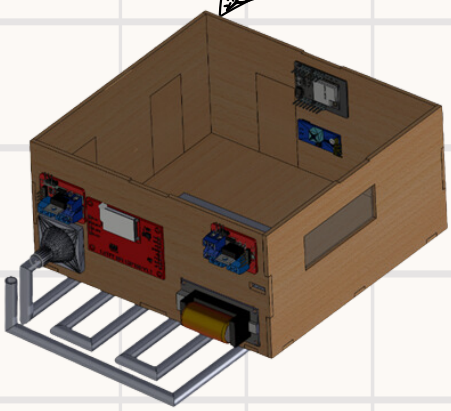
PART A
BUILDING INSTRUCTIONS

PART B
BASIC ELECTRONICS

PART C
CODING THE SMART HOUSE

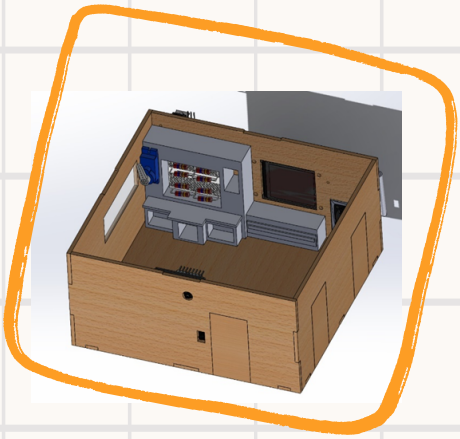
PART A BUILDING THE LIVINGROOM

3D CAD model



Step 1: Take a look at the TibkerCAD models of the smarthouse here (hyperlink) and Living Room furniture here (hyperlink)

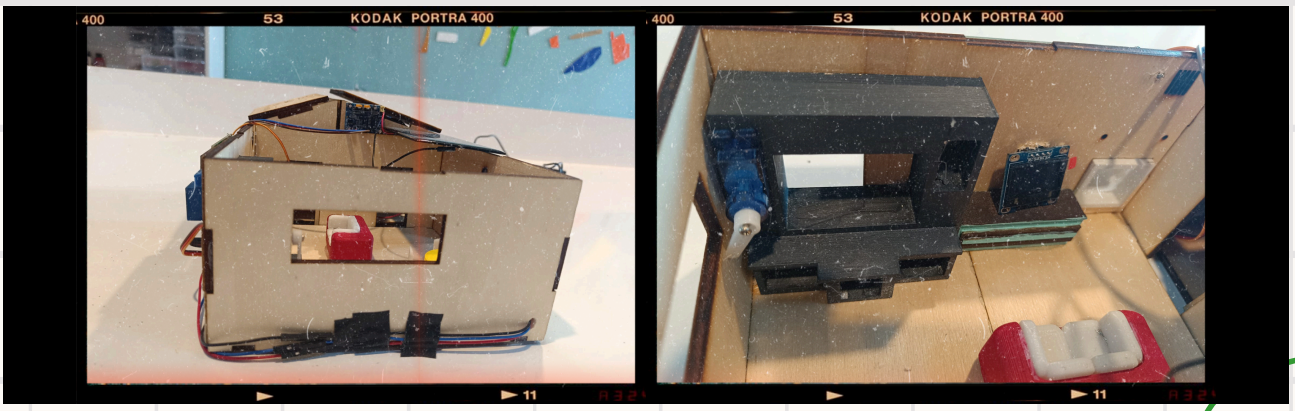
3D Printing parts



Step 2: 3-D print the materials ready for assembly

Actual build

Step 3: assemble all parts to complete the construction of the Living Room. Watch the video here: link



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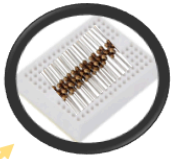
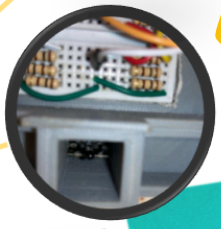




LIVING ROOM ELECTRONICS

1) Two Servo motors

Purpose: To open/close windows and doors.
Impact: Energy saving, helps with keeping the house temperature stable, lets natural light get inside the house.

YOU SHOULD KNOW THAT...

2) Solar Panel

Purpose: To power the house using renewable energy.
Impact: Lower cost, as it powered by sunlight (renewable energy), less emissions, better for the environment.

3) MOSFET Drivers

Purpose: To open and close the circuits by receiving electrical signals from outside sources (sensors)
Impact: Helps with power saving, as less energy is required

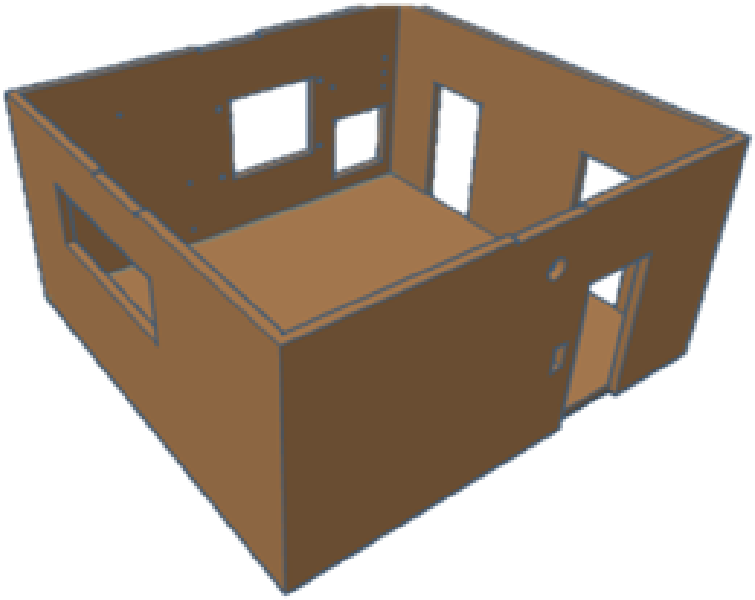
4) LCD Screen

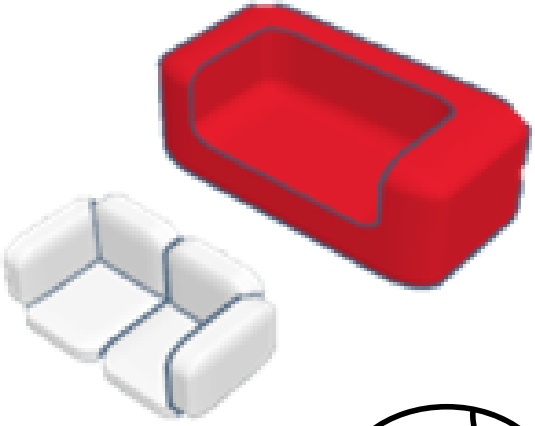
Purpose: Shows humidity and temperature details.
Impact: By controlling the humidity and temperature, we can save energy and lower carbon emissions.

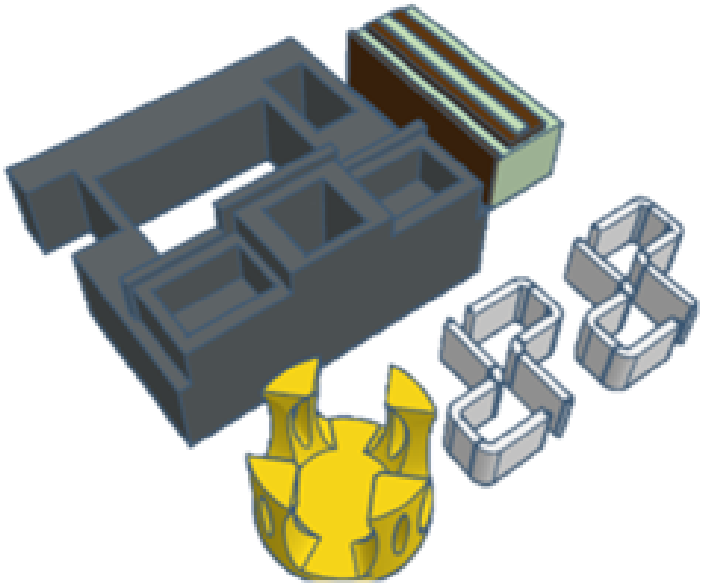
LIVING ROOM

Aim: Teach the importance of energy saving inspired on passive houses.

The aim is to control the temperature of the living room using a smart combination of heating/cooling systems.

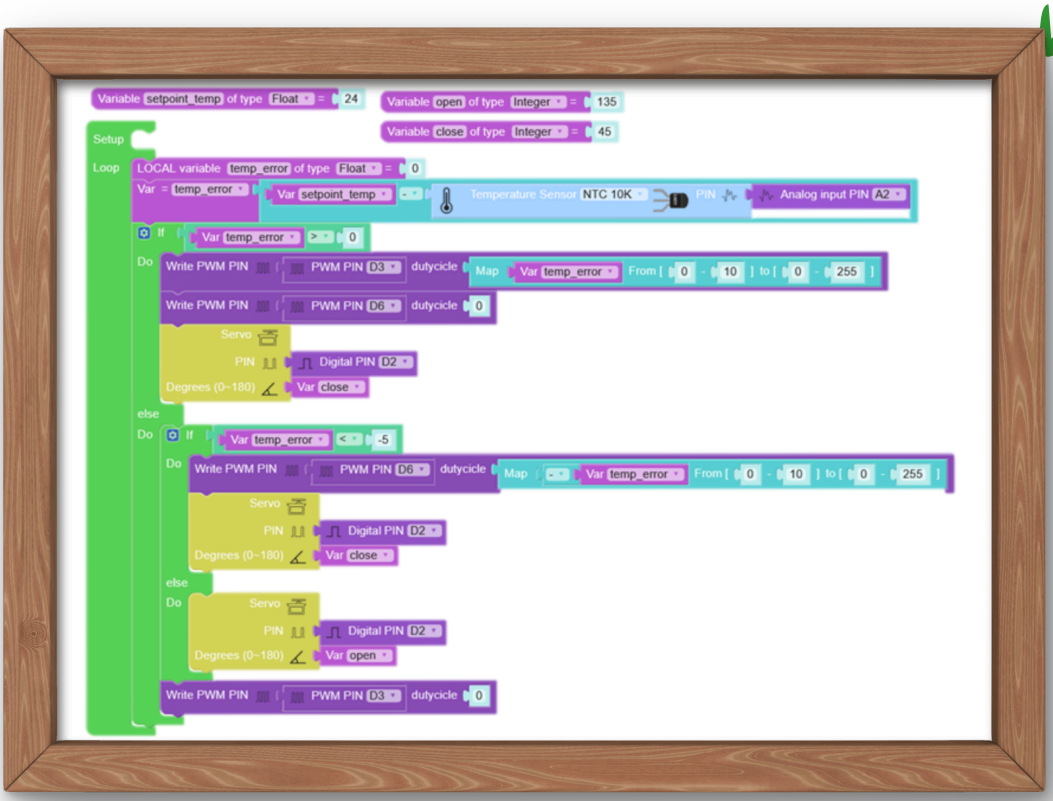






MAKE ELECTRONICS COME TO LIFE!

PART C
LIVING ROOM CODING



```
#include <Servo.h>
float setpoint_temp=24;
int open=135;
Servo _servoD2;
int close=45;
float analogNTC (uint8_t pin, float R1);
void setup(){
  pinMode(3,OUTPUT);
  pinMode(6,OUTPUT);
  _servoD2.attach(2);
}
void loop(){
  float temp_error=0;
  temp_error=setpoint_temp-(analogNTC(A2,10000));
  if (temp_error>0) {
    analogWrite(3,map(temp_error,0,10,0,255));
    analogWrite(6,0);
    _servoD2.write(close);
  }else {
    if (temp_error<-5) {
      analogWrite(6,map(-temp_error,0,10,0,255));
      _servoD2.write(close);
    }else {
      _servoD2.write(open);
    }
  }
  analogWrite(3,0);
}
```

Facilino
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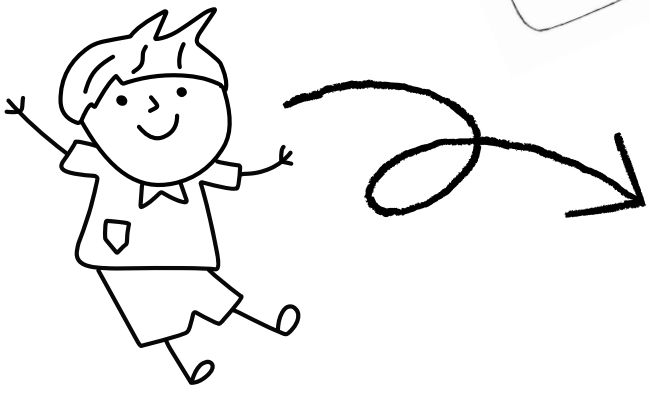
VIDEO LINKS

BASIC VIDEO EXERCISES FOR LIVINGROOM TO PROGRAM WITH FACILINO

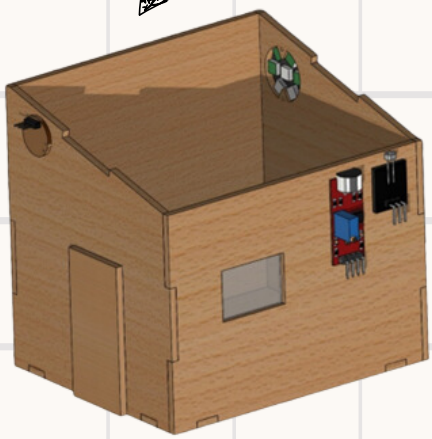
EcoThings: Programming. Living Room Temperature Control

EcoThings: Programming. Living Room Temperature Control with Energy Saving Policy



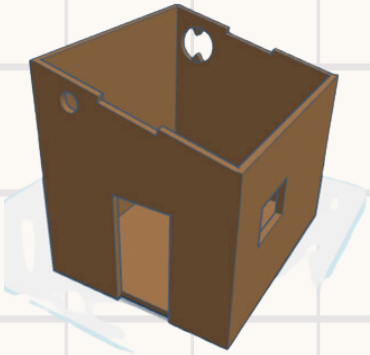
PART A BUILDING THE BEDROOM

3D CAD model

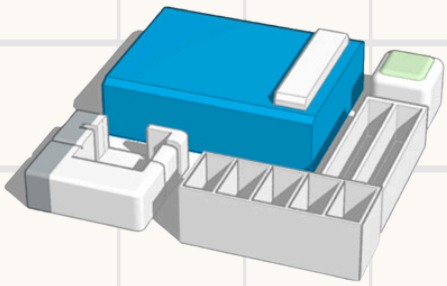


Step 1: Take a look at the TinkerCAD models of the smarthouse here (hyperlink) and bedroom furniture here (hyperlink)

3D Printing parts

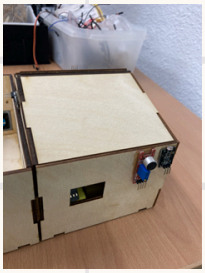


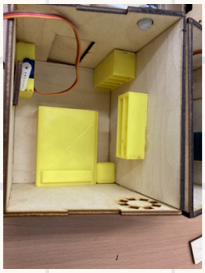
Step 2: 3-D print the materials ready for assembly

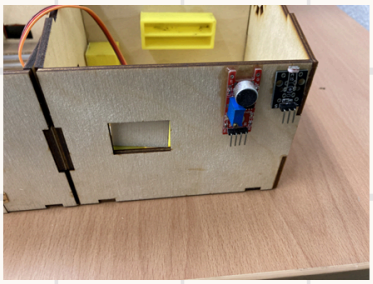


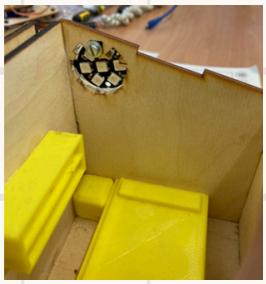
Actual build

Step 3: assemble all parts to complete the construction of the bedroom. Watch the video here: link

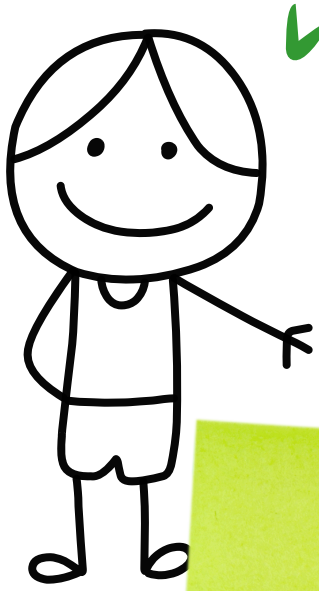








PART B BEDROOM ELECTRONICS



YOU SHOULD KNOW THAT...

1) Servo motor

Purpose: To open/close doors & windows.
Impact: Control windows and doors to maximize natural light usage

2) Light bulb

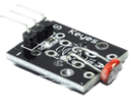
Purpose: To turn on/off based on the movement sensors.
Impact: Provide artificial light but only when necessary

3) Movement sensors

Purpose: To check for movement in order to turn the light on/off based on movement.
Impact: Optimize (minimize) light bulb usage

Bedroom Electronic Components

7 RGB LED Strip round



KY-018 Photoresistor (LDR) module

MH-SR602 PIR Sensor module

SG90 servo

KY-037 Big sound module

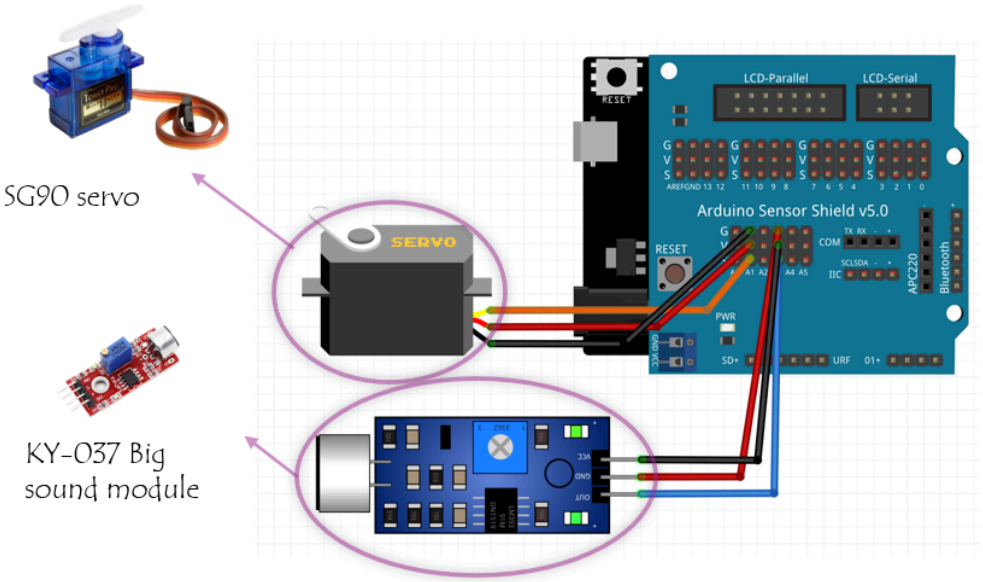
DuPont cables

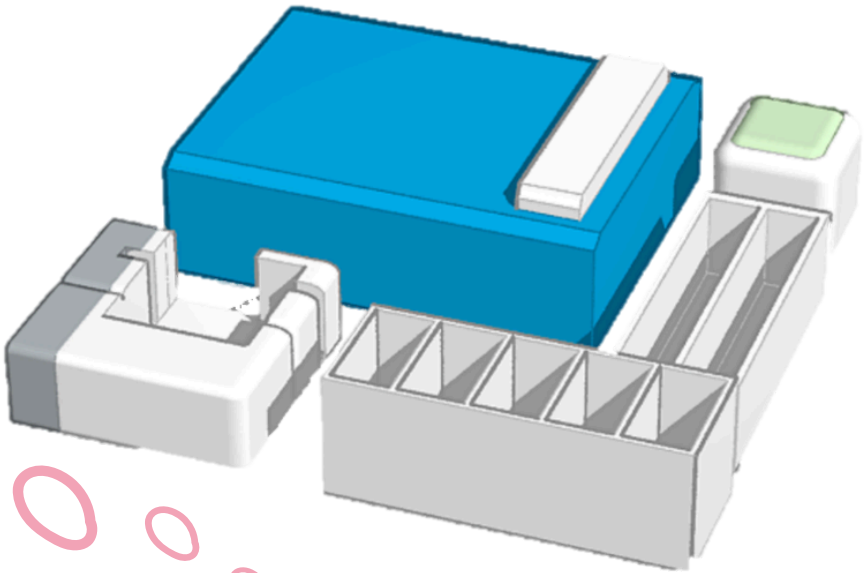
BEDROOM

Aim: Automatic control of the bedroom's lights. Also to reduce external noise.

The bedroom includes a passive infrared sensor to detect the presence of a person inside. It also uses a ligt sensor to measure ambient light and mic to measure external noises.

7 RGBs LEDs provide colored light to the bedroom
A servo motor controls the bedroom window to isolate it from external noises.





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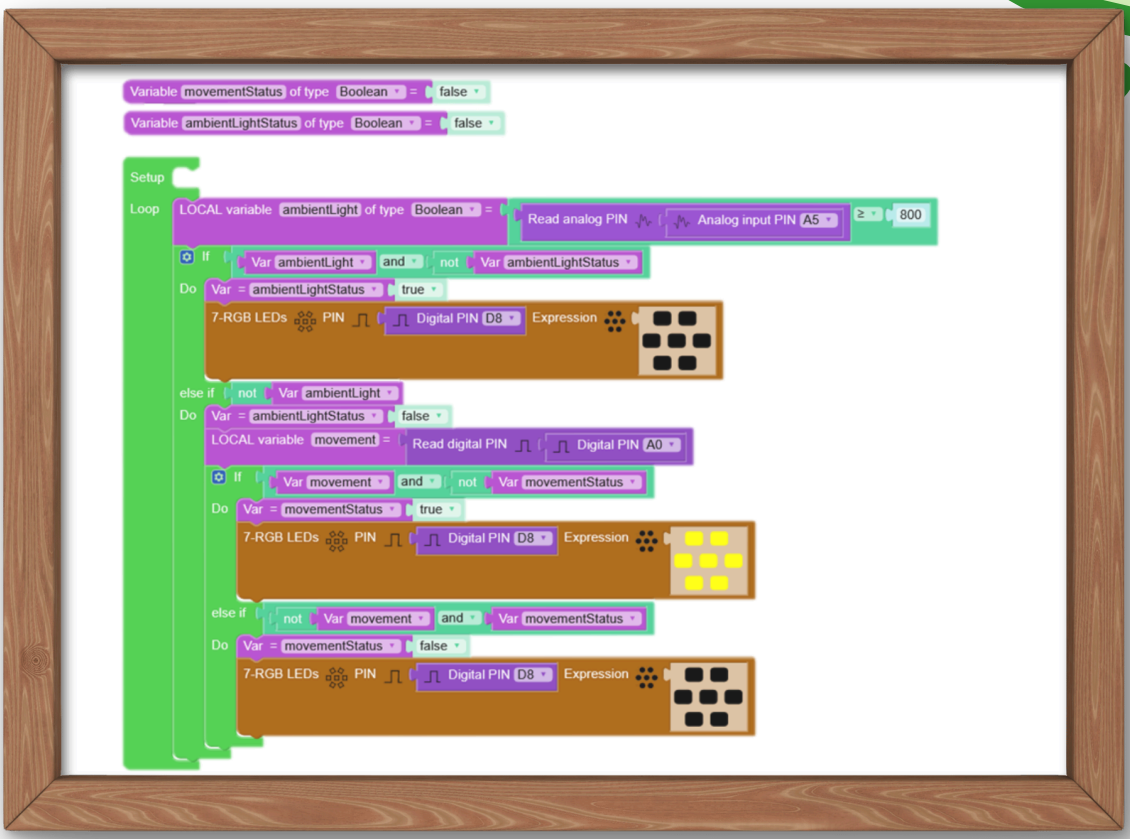
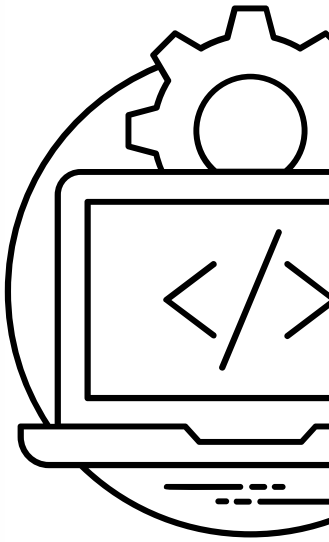
PART C
BEDROOM CODING





```
#include <Adafruit_NeoPixel.h>
bool movementStatus=false;
bool ambientLightStatus=false;
Adafruit_NeoPixel _led_strip_D8(7,8, NEO_GRB + NEO_KHZ800);
void clearpixels(…);
void writepixels(…);
void setup(){
  _led_strip_D8.begin();
  clearpixels(&_led_strip_D8);
  _led_strip_D8.setBrightness(map(10,0,100,0,255));
  pinMode(A0,INPUT);
}
void loop(){
  bool ambientLight=analogRead(A5)>=800;
  if ((ambientLight)&&(!ambientLightStatus)){
    ambientLightStatus=true;
    writepixels(&_led_strip_D8,0x000000,…);
  }
  else if (!ambientLight) {
    ambientLightStatus=false;
    int movement=digitalRead(A0);
    if ((movement) && (!movementStatus)){
      movementStatus=true;
      writepixels(&_led_strip_D8,0xffff00,…);
    }
    else if ((!movement)&&(movementStatus)){
      movementStatus=false;
      writepixels(&_led_strip_D8,0x000000,…);
    }
  }
}
```

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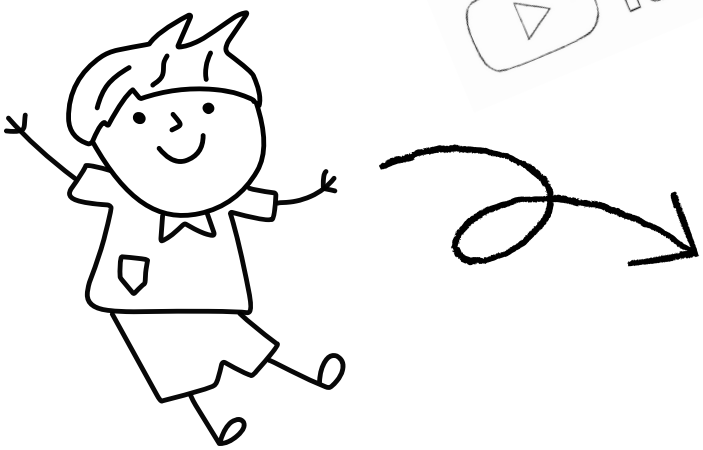
VIDEO LINKS

BASIC VIDEO EXERCISES FOR BEDROOM TO PROGRAM WITH FACILINO

EcoThings: Programming. Basic light bedroom control with Facilino

EcoThings: Programming. Bedroom Sound Control with Facilino

YouTube

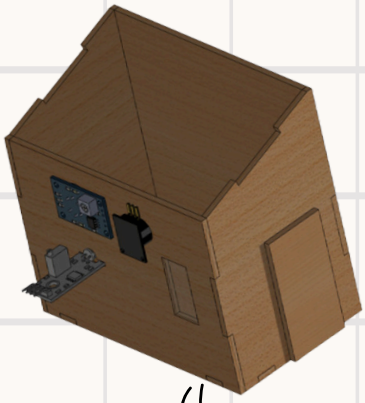


VISIT OUR YOUTUBE CHANNEL FOR ALL VIDEOS

PART A BUILDING THE KITCHEN

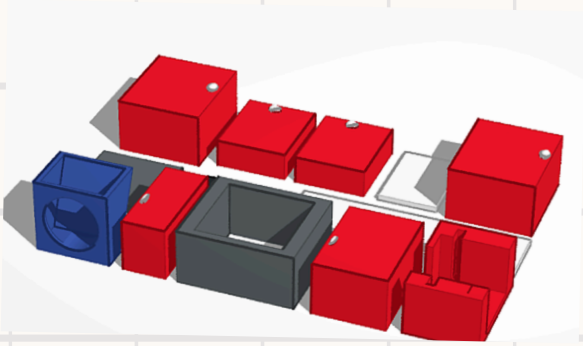
3D CAD model

Step 1: Take a look at the TinkerCAD models of the smarthouse here (hyperlink) and Kitchen furniture here (hyperlink)



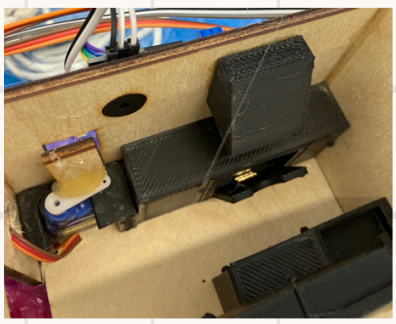
3D Printing parts

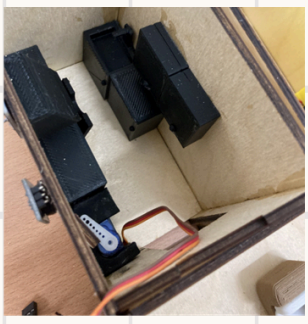
Step 2: 3-D print the materials ready for assembly

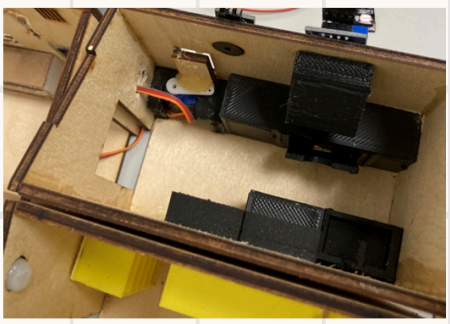


Step 3: assemble all parts to complete the construction of the Kitchen.

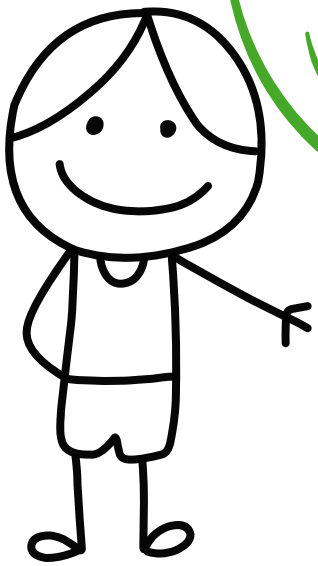
Actual build







KITCHEN ELECTRONICS



YOU SHOULD KNOW THAT...

1) Buzzer

Purpose: To notify us with a sound if there is a gas leak or a fire in the house.

Impact: For safety

2) Gas Sensor

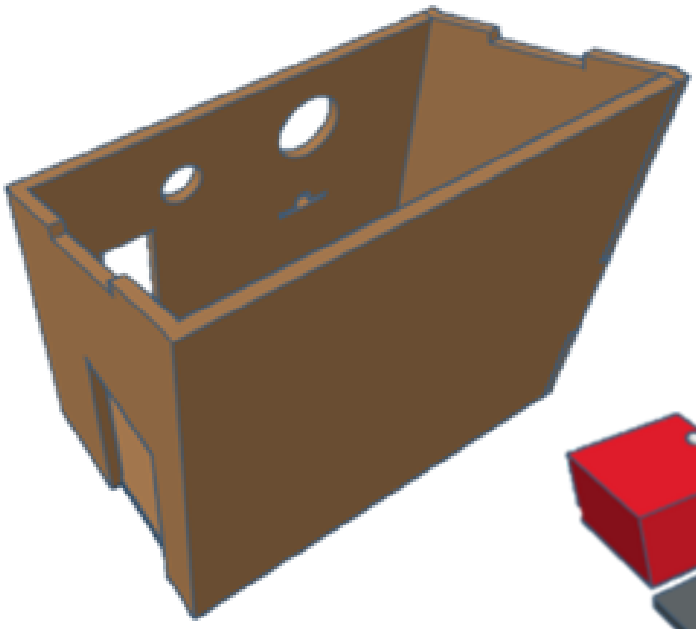
Purpose: To "sense" if there is a gas leak in the house.
Impact: For safety, since gas leak can be very dangerous for our health, and it can be more dangerous if there is also fire. Also, gas leak can be considered as energy waste.

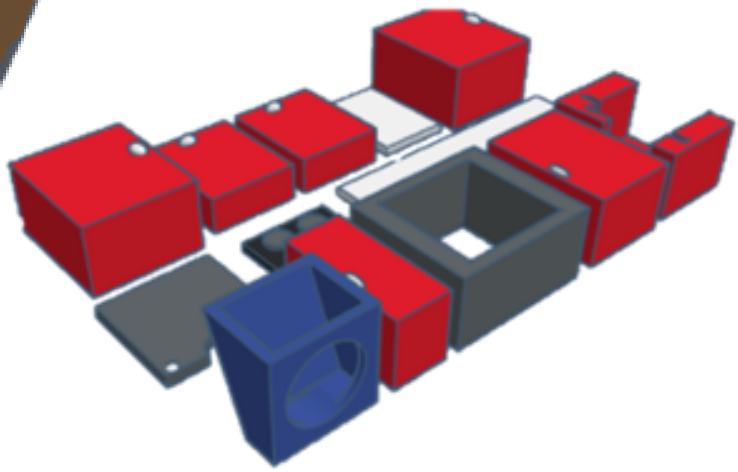
3) Fire Sensors

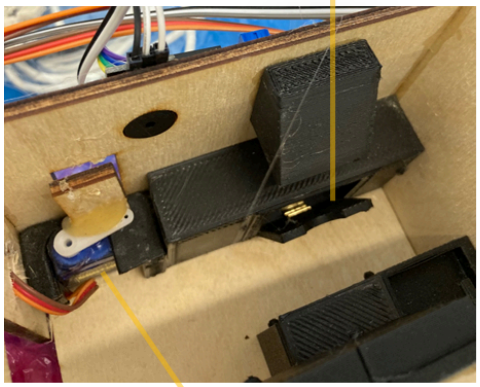
Purpose: To "sense" if there is a fire in the house.
Impact: For safety, a fire could spread inside the whole house and destroy it, putting us also in danger.

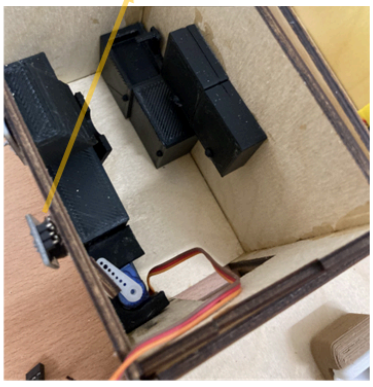
KITCHEN

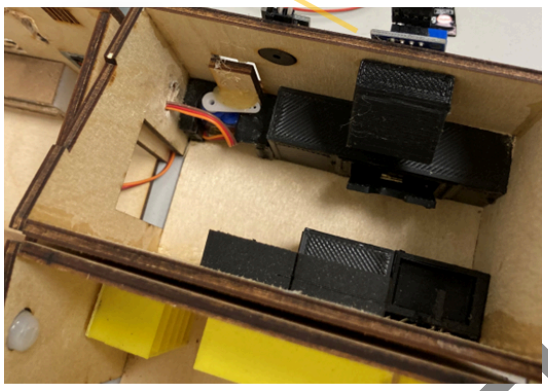
Aim: Fire and smoke detection system with beeping alarm











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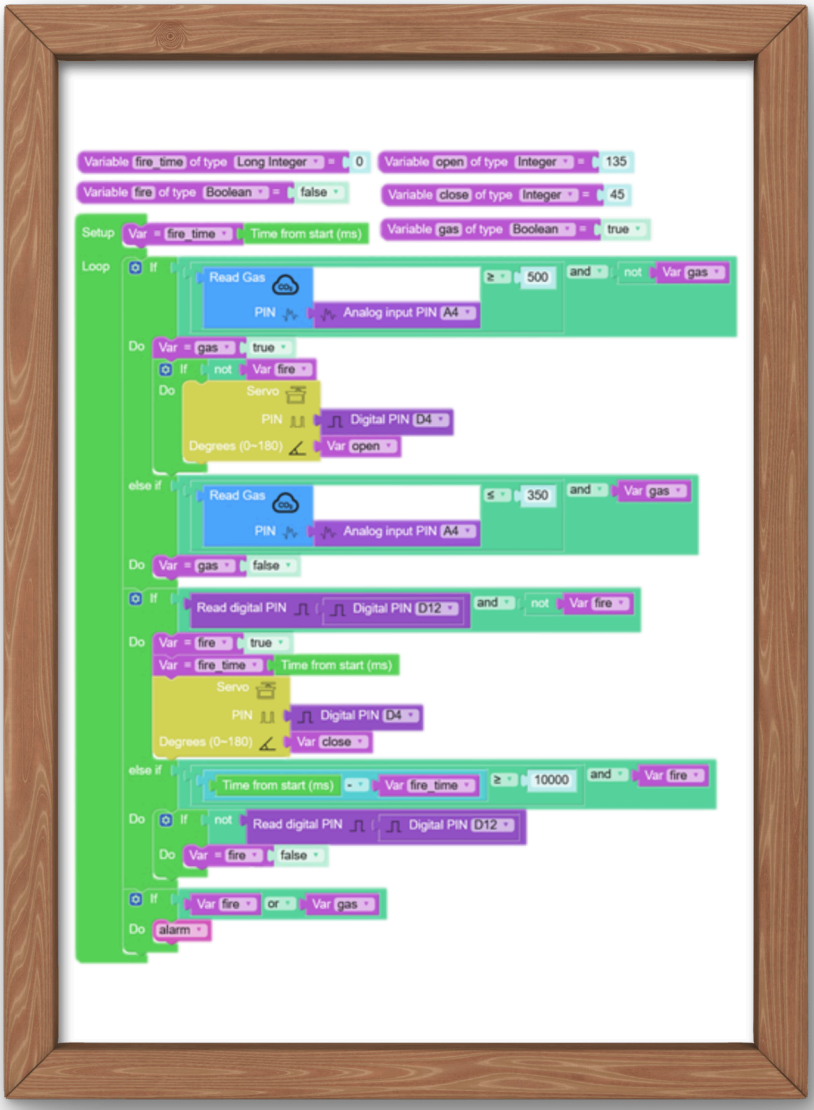
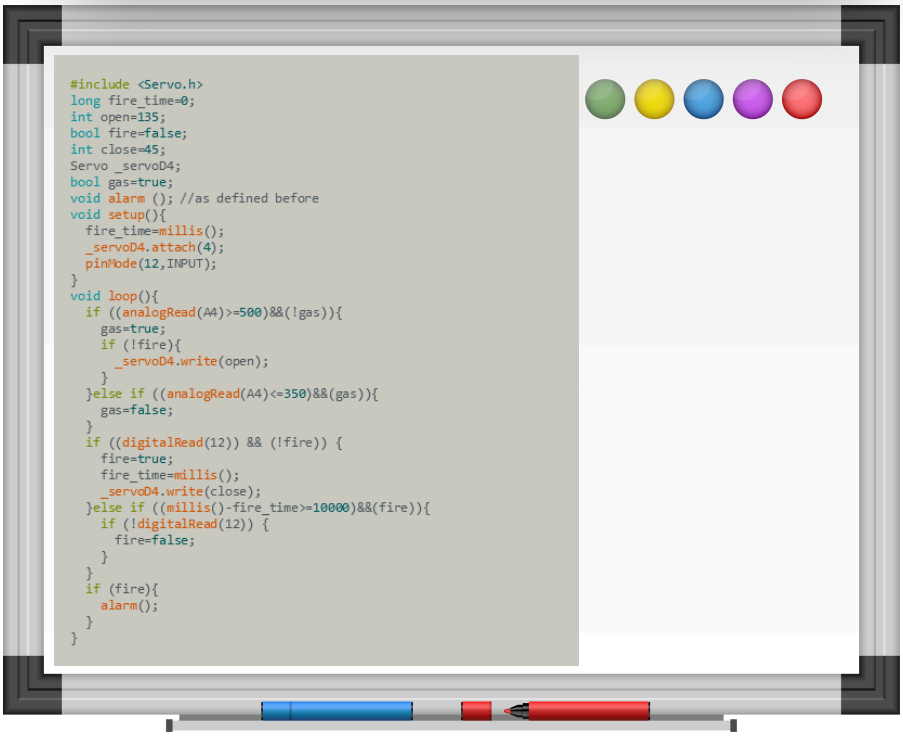
PART C
KITCHEN CODING





```
#include <Servo.h>
long fire_time=0;
int open=135;
bool fire=false;
int close=45;
Servo _servoD4;
bool gas=true;
void alarm (); //as defined before
void setup(){
  fire_time=millis();
  _servoD4.attach(4);
  pinMode(12,INPUT);
}
void loop(){
  if ((analogRead(A4)>=500)&&(!gas)){
    gas=true;
    if (!fire){
      _servoD4.write(open);
    }
  }else if ((analogRead(A4)<=350)&&(gas)){
    gas=false;
  }
  if ((digitalRead(12)) && (!fire)) {
    fire=true;
    fire_time=millis();
    _servoD4.write(close);
  }else if ((millis()-fire_time>=10000)&&(fire)){
    if (!digitalRead(12)) {
      fire=false;
    }
  }
  if (fire){
    alarm();
  }
}
```

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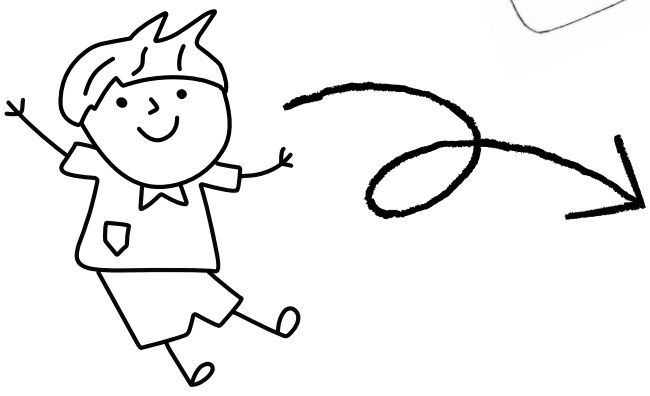
VIDEO LINKS

BASIC VIDEO EXERCISES FOR KITCHEN TO PROGRAM WITH FACILINO

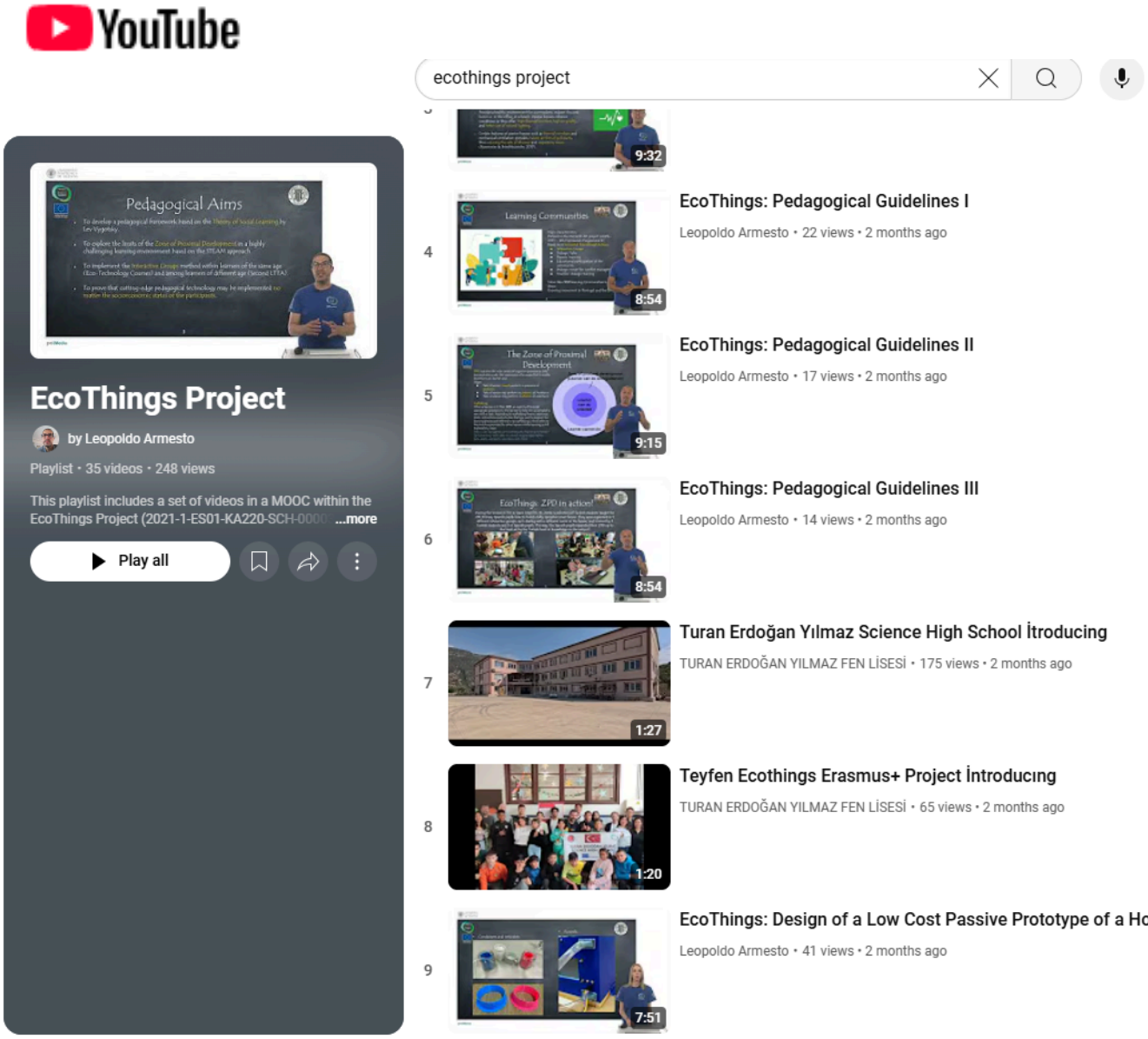
EcoThings: Programming. Kitchen Smoke Detection



YouTube

TEACHER'S RESOURCES

LEARN HOW TO PROGRAM WITH FACILINO



CLICK ON THE LINK BELOW TO ACCESS ALL TEACHER RESOURCES

[EcoTHINGS YouTube Channel]

http://

REFERENCES

1. https://github.com/roboticafacil/facilino_ai2
2. https://github.com/roboticafacil/facilino_ota
3. Blockly https://developers.google.com/blockly
4. Facilino (old version) https://roboticafacil.es/facilino/blockly/Facilino.html
5. Robótica https://roboticafacil.es
6. https://en.wikipedia.org/wiki/ESP32
7. Electropeak.com
8. https://arduinomodules.info/ky-013-analog-temperature-sensor-module/
9. https://en.wikipedia.org/wiki/Steinhart%E2%80%93Hart_equation

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